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Discriminative Validity of the Wide-Range Assessment of Memory and Learning (WRAML) With Children With and Without Attention-Deficit/Hyperactivity Disorder (ADHD).

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DISCRIMINATIVE VALIDITY OF THE WIDE RANGE ASSESSMENT OF MEMORY AND LEARNING (WRAML) WITH CHILDREN WITH AND WITHOUT ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

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DEDICATION

This dissertation is dedicated
with love and thanks to
my husband, Scott,
and my parents,
Lyn and Kathy Brewis.

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ABSTRACT

The present study examined the discriminative validity of the Wide Range Assessment of Memory and Learning (WRAML), using the individual subscales, original indexes, and a factor structure proposed by Burton, Donders, and Mittenberg (1996) that includes an Attention factor. The sample consisted of 57 non-learning disordered children who were enrolled in the first through the seventh grade and met criteria for Attention-Deficit/Hyperactivity Disorder (ADHD) and 62 Control children. The groups were matched by age, race, SES, and estimated intellectual ability. Group comparisons by MANCOVA revealed that, after controlling for the effects of math and reading achievement, differences between the groups on the subtests, original indexes, and proposed (Burton et al., 1996) factors, including the Attention factor, were not significant. Following the recommendation of Barkley (1997), the analyses were repeated by MANOVA to explore group differences regardless of discrepancies in achievement scores. Results remained statistically nonsignificant. Discriminant function analyses conducted using the individual subtests, indexes, and proposed factors show that the WRAML is a poor predictor of ADHD status. The function employing the subtests accurately placed 65 percent of each group. The index function correctly identified 55 percent of subjects (ADHD, 39 percent; Control, 70 percent), and the function using the proposed factors appropriately classified 56 percent of each group. Overall, results suggest that non-learning disordered children with and without ADHD do not score significantly differently on the subtests, indexes, or proposed factors of the WRAML.

INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most prevalent psychological disorders of childhood and one of the most common reasons for referral of children to mental health clinics (Barkley, 1998). Traditionally it has been accepted that children with ADHD exhibit developmentally inappropriate levels of inattention, motor activity, and impulsivity. However, since this cluster of symptoms was first described nearly 100 years ago, debate has continued over the nature of the core deficit involved in the disorder (e.g., Laufer & Denhoff, 1957; Douglas, 1972; Barkley, 1997; Jensen et al., 1997). Naturally, this controversy has resulted in many different approaches to the assessment and diagnosis of attention problems (e.g., Culbertson & Krull, 1996; Barkley, 1998; Sattler, 1992; Erdman, 1998). This wide variation in assessment methods has, in turn, led to such heterogeneity in the clinical presentation of disorder that some researchers have questioned the validity of ADHD as a clinical entity (e.g., Goodman & Poillion, 1992; Reid, Maag, & Vasa, 1993).

Research continues to examine ways in which children who express these symptoms do and do not differ from "normal" children and children with other medical, developmental, and psychological disorders. The desire has been to identify an objective test or group of tests that differentiates this group with greater accuracy than can be achieved by using base rates. Although some measures have shown initial promise (e.g., Milich & Loney, 1979), further research has failed to support their use as anything more than an adjunct to the assessment and diagnosis of ADHD (e.g., Riccio, Cohen, Hall, & Ross, 1997; Cohen, Becker, & Campbell, 1990). It is hoped that continued comparison of the performance of children with and without ADHD on a variety of clinical measures will not only improve diagnostic capabilities, but will clarify the very nature of the disorder.

The Wide Range Assessment of Memory and Learning (WRAML; Sheslow & Adams, 1990) is one measure that has shown initial promise in discriminating children with and without ADHD. Comparisons of such groups on the nine individual subtests seem to suggest that the groups score differently (e.g., Adams, Sheslow, Robins, & Wilkinson, 1993; Mealer, Morgan, & Luscomb, 1996), while results from studies examining the three more global indexes have been mixed (e.g., Phelps, 1996; Adams et al., 1993). Recent studies have questioned the validity of these indexes and suggested several alternative factor solutions (e.g., Phelps, 1995; Aylward, Gioia, Verhulst, & Bell, 1995). A statistically sound and clinically meaningful solution identified by Burton, Donders, and Mittenberg (1996) includes a proposed Attention factor. However, the discriminative validity of this structure has not yet been tested. If this structure differentiates children with and without ADHD, then it may be a useful tool in clinical assessment. Regardless, an examination of the performance of children with and without ADHD on this test should further our understanding of how children with this disorder do and do not differ from their nondisordered peers.

REVIEW OF LITERATURE

Attention-Deficit/Hyperactivity Disorder

The current diagnostic criteria for Attention-Deficit/Hyperactivity Disorder (ADHD) follow decades of change in the conceptualization of the disorder. Through the first half of this century, researchers viewed the problems of inattention, hyperactivity, and behavioral disinhibition as resulting from central nervous system (CNS) insult (Barkley, 1998). Still (1902) is frequently cited as the first clinician to describe a cluster of behaviors similar to the modern diagnosis of ADHD. He described a group of children presenting to his clinic with the symptoms of inattention, overactivity, and disinhibition. He described these children as resistant to discipline, emotionally labile, oppositional, and lacking in morals. Early research on this syndrome established a link between brain damage and inattention, impulsivity, and hyperactivity, leading to a biological view of ADHD that remains popular today (Culbertson & Krull, 1996).

The link between the symptoms of ADHD and brain injury led to the conceptualization of minimal brain dysfunction (MBD) syndrome, a diagnostic label popular in the 1960's. Researchers theorized that the behaviors associated with MBD were the result of undetected brain damage early in development. However, with no neurological evidence to support this theory, the MBD label fell out of use (Barkley, 1998). As the popularity of MBD waned, the focus shifted from inferred brain damage to the high level of activity often seen in children with this disorder. The labels "hyperkinetic child syndrome" (Laufer & Denhoff, 1957) and "hyperactive child syndromes" (Chess, 1960) were born. This new perspective led to the inclusion of the diagnosis "Hyperkinetic Reaction of Childhood" in the second edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-II;* American Psychiatric Association, 1968).

By the 1970's the focus again began to shift. The emphasis on hyperactivity gave way to interest in the apparent inability of these children to sustain attention (e.g., Douglas, 1972). Researchers began to view hyperactivity as a common but not universal characteristic of the disorder. The third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-III*; American Psychiatric Association, 1980) adopted the diagnosis Attention Deficit Disorder (ADD) and defined two subtypes based on the presence or absence of comorbid hyperactivity. The publication of the *DSM-III* led to criticism of the subtypes, because many felt that sufficient research on the validity of the distinction did not yet exist (Culbertson & Krull, 1996). In the revised third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-III-R*; American Psychiatric Association, 1987), the diagnosis became known as ADHD, combining the dimensions of inattention and hyperactivity into a unidimensional construct with a single symptom list. The subtype of ADD without hyperactivity remained only as the vague and virtually parenthetical diagnosis of Undifferentiated Attention-Deficit Disorder. Interest in the validity of the subtypes, however, remained strong, and controversy over their existence spawned many research studies (e.g., Barkley, DuPaul, & McMurray, 1990; Goodyear & Hynd, 1992; Lahey, Schaughency, Hynd, Carlson, & Vieves, 1987).

Current Diagnostic Criteria. Field trials conducted during the development of the fourth and current edition of the *Diagnostic and Statistical Manual of Mental*

Disorders (*DSM-IV*; American Psychiatric Association, 1994) appeared to support the existence of three subtypes of ADHD, and the conceptualization of the disorder shifted again. The current criteria (see Appendix A) allow for the presence of developmentally inappropriate levels of inattention and/or hyperactivity-impulsivity (American Psychiatric Association, 1994). This allows for three distinct presentations of the disorder. The labels "Predominantly Inattentive Type" and "Predominantly Hyperactive-Impulsive Type" reflect the presence of significant problems primarily in only one of these domains, while the specifier "Combined Type" reflects the presence of significant problems in both areas. In addition, the category Attention-Deficit/Hyperactivity Disorder Not Otherwise Specified is appropriate for individuals who experience significant dysfunction due to any of the primary symptoms of ADHD, without meeting full criteria for the disorder (American Psychiatric Association, 1994).

Even with standardized diagnostic criteria, the clinical presentation of ADHD can be amazingly diverse. The inattention characteristic of ADHD may be exhibited as a deficit in sustained attention, a failure to attend to details, disorganization in task completion, distractibility, or forgetfulness. Hyperactivity can similarly take the form of fidgeting, excess motor activity, seemingly inexhaustible energy, or difficulty playing or working quietly. Impulsivity or behavioral disinhibition is exhibited as impatience, interrupting or intruding on others, or acting without considering the consequences of one's behavior (American Psychiatric Association, 1994).

Restrictions on diagnosis include the persistence of the problems for at least six months, the onset of at least some problem behaviors before the age of seven, impairment to some degree across multiple settings (e.g., home, school, or work), and significant impairment in everyday functioning in one or more settings. Exclusionary criteria disallow a diagnosis of ADHD when the symptoms are better explained by another mental disorder (i.e., mood, anxiety, dissociative, or personality disorder) or occur exclusively within the context of a Pervasive Developmental Disorder, Schizophrenia, or other psychotic disorder (American Psychiatric Association, 1994).

Barkley (1990, 1998) proposed that several additional restrictions be placed on the diagnosis of ADHD. To enhance the reliability and validity of ADHD as a diagnosis, as well as to quantify the developmental inappropropriateness of a child's behavior, Barkley (1998) suggested that a child not be diagnosed with ADHD unless he or she is rated more than one and a half standard deviations above the mean (approximately 93rd percentile) on standardized behavior rating scales completed by parents, teachers, or both. To account for developmental changes in the normal expression of the behaviors associated with ADHD, Barkley (1990, 1998) suggested that diagnosis during the preschool years be reserved for those children exhibiting high levels of these behaviors for at least 12 (as opposed to six) months or beyond four years of age. Barkley (1990) also proposed that preschoolers be required to meet more, and adolescents to meet fewer, criteria than school-aged children.

Barkley (1997) has developed a new theory that may cause another significant shift in the conceptualization of ADHD. He recently proposed that ADHD is not a disorder of inattention or hyperactivity, but a developmental delay in behavioral inhibition. He contends that the hyperactivity and certain forms of inattention associated with the disorder are secondary to the more basic impairment in inhibition. Furthermore, poor inhibitory skills lead to deficits in the executive functions, identified by Barkley as nonverbal working memory; verbal working memory (internal speech); self-regulation of affect/motivation/arousal; and reconstitution or the ability to break down a complex behavior into its constituent parts and recombine the discrete movements into a new behavior. This theory has strong implications for the assessment of ADHD, suggesting that measures of the various facets of behavioral inhibition would be the most successful at identifying individuals with the disorder. He adds that measures of executive function could be helpful in the assessment of individuals at risk for ADHD. He is quick to point out, however, that performance on tests of executive functions could be affected by many biological, psychological, and environmental difficulties, including but not limited to ADHD.

ADHD and Memory

Although the diagnostic criteria for ADHD make only a cursory reference to memory problems, research has shown that children with ADHD score lower on certain types of memory tasks. Results are far from conclusive, however, and it is unknown whether the lower scores on these measures result from memory deficits or, as several researchers (e.g., Barkley, 1990; Blondis, Accardo, & Snow, 1989) have suggested, the effects of ADHD in the testing situation. No matter the nature of the causal relationship, any reliable pattern of scores on a well-standardized test may prove useful in the assessment and understanding of the disorder.

Word Lists. Studies comparing the memory skills of children with and without ADHD have focused primarily on verbal memory. Many studies compared the ability of children with and without ADHD to memorize a list of words over several trials. The Rey Auditory-Verbal Learning Test (RAVLT; Rey, 1964, Taylor, 1959, as cited in Lezak, 1983) consists of five presentations of a 15-word list, one presentation of a different 15-word interference list, and a delayed postinterference recall of the original list. Several researchers (e.g., Mungas, 1983; McGee, Williams, Moffitt, & Anderson, 1989) found no difference between individuals with and without ADHD on the RAVLT. However, Felton, Wood, Brown, Campbell, and Harter (1987) found that children with ADHD remembered fewer words than children without ADHD on the first, fifth, and postinterference trials. Their scores did not differ significantly on the interference trial. Frost, Moffitt, and McGee (1989) examined the neuropsychological functioning of a cohort of 13-year-olds and found that children with ADHD scored more poorly on a group of verbal memory tasks that included the first, last, and delayed recall trials of the RAVLT.

Differences have been found more consistently in studies using the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987). The CVLT consists of 11 learning trials of a 16-word list. Holdnack, Moberg, Arnold, Gur, and Gur (1995) found that adults with ADHD recalled fewer words on all trials, except the interference trial, and were more negatively affected by the interference trial. Loge, Staton, and Beatty (1990) used a child's version of the CVLT that includes five learning trials of a 12-word list, an interference trial, short-term and delayed postinterference trials of the original list, and a recognition trial of the original list. The list contains four words from each of three categories (clothing, fruit, and vegetables). Loge et al. (1990) found that children with ADHD recalled fewer words than children without ADHD on all but the third, interference, and recognition trials.

Mariani and Barkley (1997) compared preschool boys with ADHD with a group of comparison subjects and found no difference in their performance on the Wisconsin Selective Reminding Test--Preschool Version (WSRT-PV; Newby, 1988). On the WSRT-PV, the examiner reads a list of six unrelated words and prompts the child to repeat as many as possible. The examiner then reminds the child only of those words omitted and prompts the child to repeat the entire list again. This continues for eight trials or until the child has successfully recalled the entire list on three consecutive trials.

Ackerman, Anhalt, Dykman, and Holcomb (1986) compared children with two forms of ADHD--with and without hyperactivity--to a group of control children. They tested the children's recall of 20 sets of three words. Within each set, two of the words were either acoustically or semantically related. After controlling for IQ, they found no difference in the recall of acoustically or semantically related words. Ackerman et al. (1986) then compared the groups' recall of a 12-word list across eight learning trials and on an approximately two-hour delayed recall trial. The list consisted of six high-imagery and six low-imagery words. Compared with the control group, both groups of children with ADHD recalled fewer low-imagery words during the learning trials, while the nonhyperactive ADHD group also recalled fewer high-imagery words. On the delayed recall trials, no differences were found on the recall of high-imagery words, while both ADHD groups recalled fewer low-imagery words.

Borcherding, et al. (1988) found that a group of boys with ADHD recalled significantly fewer words from two lists of 12 words--one consisting of related words and one made of unrelated words. Loge, et al. (1990) used the Brown-Peterson technique to test the ability of children to recall four unrelated words, preventing rehearsal by having the children count backwards between list presentation and recall. They found that children with ADHD recalled fewer words and falsely inserted more words than did children in the control group.

Voelker, Carter, Sprague, Gdowski, and Lachar (1989) systematically examined the effect of list structure on the performance of children with and without ADHD. The experimental task consisted of 12-word lists clustered or unclustered and contained words that were acoustically related, semantically related, or unrelated. After controlling for age, intellect, and achievement, they found that the children with ADHD remembered significantly fewer words only from the semantically related but unclustered list. The authors attributed the selectively poor performance of the ADHD group to their failure to use strategies spontaneously when such an approach was not obvious as it was in the clustered lists. This is consistent with the executive dysfunction theories of ADHD.

Paired Associates Learning (PAL) Tasks. Douglas and Benezra (1990) administered a paired associates learning (PAL) task involving related and unrelated pairs of monosyllabic words. They found that boys with ADHD recalled and recognized significantly fewer unrelated pairs than boys in the control group. No difference was found on the recall or recognition of related pairs.

Sentences. Siegel and Ryan (1988) found no difference in the ability of ADHD and control children to repeat 10 sentences verbatim. Higginbotham and Bartling (1993) used a longer series of increasingly more complex sentences and found that the groups did not differ on the first 10 sentences, which were relatively simple. However, the performance of the children with ADHD deteriorated greatly as the difficulty level increased, leading to significant differences on the second and third groups of ten sentences. This pattern was interpreted as indicating that the children with ADHD became more quickly overwhelmed as the material to be recalled increased. However, this deterioration seemed limited to situations in which material had to be recalled verbatim.

Stories. Several researchers have compared the ability of children with and without ADHD to recall short stories and have consistently found no difference in immediate (e.g., Felton, et al., 1987; O'Neill & Douglas, 1991; Shue & Douglas, 1992) or delayed prose recall (Felton et al., 1987; Shue & Douglas, 1992). Tannock, Purvis, and Schacher (1993) found no difference in the immediate recall of main ideas but did find that children with ADHD remembered less information overall, included more inaccurate information, and organized their recall more poorly than the control group.

Digit Span. Other popular methods of assessing memory are the digit span tests and their variations. Many researchers have compared individuals with and without ADHD on their ability to recall series of numbers verbatim, and results, again, have been far from consistent. Several researchers found no significant differences (Benezra & Douglas, 1988; Shue & Douglas, 1992; Breen, 1989), while others found significant deficits in recall for individuals with ADHD (Chelune, Ferguson, Koon, & Dickers, 1986; Arcia & Gualtieri, 1994; Mariani & Barkley, 1997).

Visual/Spatial Memory. Research on visual memory has also produced mixed results. Using the delayed recall prompt of the Rey-Osterrieth Complex Figure Test (R-OCFT; Rey, 1941, Osterrieth, 1944, as cited in Lezak, 1983), McGee, et al. (1989) found no difference between a group of children with ADHD and a control group. Similarly, in their investigation of a 13-year-old cohort, Frost, et al. (1989) found that children with ADHD did not differ from a nondisordered group on a visual-spatial factor that included the R-OCFT copy and delayed recall scores.

In contrast, Cahn and her associates (1996) compared the performance of children with ADHD on the R-OCFT to that of age-matched controls and found that the children with ADHD scored significantly lower on several measures. Furthermore, performance on the R-OCFT displayed a sensitivity of 64 percent and specificity of 97 percent, correctly classifying 81 percent of the children. Their findings suggest that a poor performance on the R-OCFT is a good indicator of risk for ADHD, but adequate performance does not necessarily rule out attention problems.

Massman, Nussbaum, and Bigler (1988) examined the correlation between the Child Behavior Checklist (CBCL) Hyperactivity scale and several neuropsychological measures. They found that scores on the Benton Visual Retention Test (BVRT; Benton, 1974, as cited in Lezak, 1983) were negatively correlated with the CBCL Hyperactivity ratings for children aged nine to 12, but not for those aged six to eight.

Arcia and Gualtieri (1994) found that adults with ADHD made more errors when asked to identify previously presented 10 by 10 black and white arrays. Also, Agrawal and Kaushal (1987) found that boys with ADHD made more errors when asked to recall red, black, or all elements from two-by-four alphanumeric arrays. Ott and Lyman (1993) compared children with and without ADHD on a spatial location memory task. Although the groups did not differ on their memory for location, the children with ADHD recalled significantly fewer items overall. In contrast, Siegel and Ryan (1988) found no difference in the ability of children with and without ADHD to recall five-letter series printed on cards, and Douglas and Benezra (1990) found no difference on the recall of 12 words presented both verbally and visually.

At least two studies have used elements of the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983) and found mixed results. In a study of the performance of preschool boys with ADHD on a variety of neuropsychological and academic measures, Mariani and Barkley (1997) found that the preschool boys with ADHD performed more poorly on the Hand Movements and Spatial Memory subtests of the K-ABC. The Hand Movements task requires children to reproduce increasing series of discreet hand movements demonstrated by the examiner (Kaufman & Kaufman, 1983). The Spatial Memory subtest requires the children to recall the location on a page of previously presented pictures (Kaufman & Kaufman, 1983). Breen (1989) compared girls and boys with ADHD to girls without ADHD and found no differences on the Spatial Memory subtest. However, this study is limited by the lack of male subjects in the control group, because at least one study has found that females score lower than males on this task (Brown, Madan-Swain, & Baldwin, 1991).

Sequential Memory. Gorenstein, Mammato, and Sandy (1989) conducted a study using two sequential memory tasks. On one task, children were briefly shown two illustrated scenes in sequence and were then asked to identify each scene from a selection of several similar possibilities. The second task involved the experimenter turning over a deck of cards one by one. Each card had either a plus or minus sign on it. Each time a card was presented, the child was asked to identify the sign on the card presented two cards previously. They found that inattentive and hyperactive children made more errors on both tasks.

Summary. In summary, research is far from conclusive regarding deficits on tests of memory in children with ADHD. However, research findings suggest the possibility of reliable differences between children with and without ADHD on certain types of memory tasks. On tests requiring the learning of a list of words, differences have been found most often when the use of a strategy (e.g., grouping words into categories) would aid performance but this strategy was not made obvious, as by the clustering of words during list presentation. Differences have been found less often when the lists consisted of unrelated words or words grouped during presentation. Therefore, it has been suggested that the performance of children with ADHD suffers not due to a memory deficit per se, but from a failure to use effective learning strategies spontaneously. This is consistent with theories of disinhibition and executive dysfunction in ADHD (e.g., Barkley, 1997; Pennington & Ozonoff, 1996). Recalling sentences verbatim may be particularly difficult for children with ADHD, especially when the sentences increase in length or complexity. However, these children appear to have no difficulty recalling main ideas from short stories. Data from digit span tests have been inconclusive, likely depending--much as with word lists--on the structure of the individual test items. The small number of studies using visual memory tests suggest a trend similar to that seen on verbal tests. Children with ADHD have had more difficulty when asked to recall items exactly or to repeat sequences of stimuli rather than simply to reproduce the general structure or content of the test item.

Medication Effects on Memory Tasks

Little research has examined the effect of stimulant medication on subjects' performance on memory tasks, and existing research often seems contradictory. Most of the research in this area has used visual recognition and PAL tasks. Several researchers found that methylphenidate reduced the number of errors made on a visual number or letter recognition task by subjects with (e.g., Coons, Klorman, & Borgstedt, 1987; Klorman, Brumaghim, Fitzpatrick, Borgstedt, & Strauss, 1994; Klorman, Brumaghim, Fitzpatrick, & Borgstedt, 1992) and without (Peloquin & Klorman, 1986) ADHD. However, Aman, Marks, Turbott, Wilsher, and Merry (1991) found no effect for methylphenidate on a picture recognition task by intellectually subaverage children. O'Toole, Abramowitz, Morris, and Dulcan (1997) conducted a placebo-controlled study and found dose-related improvements in the performance of children with ADHD on both easy and difficult nonverbal learning and memory tasks.

Other researchers examining the effects of methylphenidate found a significant improvement on a PAL task involving bigrams of letters and single digits (Rapport, Carlson, Kelly, & Pataki, 1993). In contrast, Kupietz, Winsberg, Richardson, Maitinsky, and Mendell (1988) found no medication effect on a task of pairing Chinese characters to their English counterparts. Pozzi and Hartley (1984) used a task of pairing primary and secondary figures and found no medication effect on immediate recall but a positive medication effect on delayed recall when the original learning took place in a medicated state. However, Rapport, Loo, and Denney (1995) questioned the use of PAL tasks in pharmaceutical research after finding that some children who show academic and behavioral improvement do not improve on PAL tasks.

DeSonneville, Njiokiktjien, and Hilhorst (1991) found that methylphenidate did not affect subjects' scores on a digit span task or the Benton Visual Retention Test. Evans, Gualtieri, and Amara (1986) examined the effect of several dosage levels of methylphenidate on the ability of children with ADHD to recall a 10-word list in an eight-trial selective reminding test. They found a significant positive effect only for the highest dosage level on the delayed recall prompt.

Only one study was found that examined the effect of stimulant medication on WRAML performance. Corte (1994) compared the performance of children diagnosed with ADHD with or without a comorbid learning disorder. Each child took the WRAML twice, once after taking a standardized dose of methylphenidate and once after taking a placebo. The order of these conditions was randomized across subjects. No overall effect for medication was found, although the children with comorbid learning disorders did show an improvement in Visual Memory Index. This study, however, suffered several significant limitations. First, the small sample size of 20 subjects limited the statistical power of the analyses. Second, medication effects were measured using only the original WRAML indexes, the validity of which has been repeatedly called into question. Third, methylphenidate dosages were determined by body mass rather than by therapeutic effect.

Based on available research, it appears that stimulant medication may improve performance on verbal tasks, but results of visual tasks are inconsistent. Research in this area is sorely lacking.

Wide Range Assessment of Memory and Learning (WRAML)

The Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990) was developed to provide a reliable, age-normed measure of the memory skills of school-aged children in a clinical setting. The standardization sample consisted of 2363 children stratified by age, gender, race, urban or rural area, socioeconomic status, and geographic region.

Structure of the WRAML. The WRAML consists of nine immediate recall subtests, four delayed recall tests, and one delayed recognition test. While the authors acknowledge that the test is not a comprehensive measure of memory, its components were designed and selected to sample a clinically meaningful variety of learning and memory skills. Scores from the subtests are combined to form a General Memory Index and grouped into three mutually exclusive indexes that ostensibly measure Verbal Memory, Visual Memory, and Learning.

The Verbal Memory Index is made up of the Story Memory, Sentence Memory, and Number/Letter subtests, all of which require the child to repeat information read by the examiner. Story Memory consists of two short stories, Sentence Memory includes sentences of increasing length and complexity, and Number/Letter is made of increasing series of numbers and letters.

The Visual Memory Index is a composite of the Picture Memory, Design Memory, and Finger Windows subtests. On Picture Memory, the child is briefly shown an illustrated scene. He is then shown another similar scene on which he must identify any elements added or changed. Design Memory asks the child to reproduce complex geometric designs presented for only a few seconds each. Finger Windows is a visual sequential memory task on which the child reproduces a pattern modeled on a plastic board by the examiner.

The Learning Index contains the three subtests--Verbal Learning, Sound Symbol, and Visual Learning--that involve presentation of stimuli over several trials. Verbal Learning is a word list task consisting of unrelated words. Sound Symbol is a paired associates learning task on which the child must learn to pair nonsense syllables with novel figures. Visual Learning resembles a popular children's game, Memory, and requires that the child identify the location of designs on a grid.

Reliability. Estimates of internal consistency for the subtests were computed for 21 different age groups using the coefficient alpha. Median coefficients for the tests ranged from .78 (Verbal Learning) to .90 (Sound Symbol). Test-retest reliability was also assessed with the authors using long intertrial intervals (minimum 60 days) to reduce carry-over effects. They reported stability coefficients ranging from .61 (Visual Memory) to .84 (General Memory) for the four published indexes. Stability ratings for individual subtests were not provided. The median standard error of measurement (SEM) ranged from .9 (Sound Symbol) to 1.3 (Picture Memory, Verbal Learning, and Finger Windows).

Criterion-Referenced Validity. To assess the validity of the WRAML, the authors relied primarily on criterion-referenced validity. They compared the WRAML index scores with the McCarthy Scales of Children's Abilities Memory Index (ages six and seven), the Stanford Binet--Fourth Edition Short-Term Memory (ages 10 and 11), and the Wechsler Memory Scale-Revised (ages 16 and 17). The authors report moderate to high correlations between the WRAML subtests and other instruments that purport to assess memory skills in children. However, as with the test-retest data, information is provided only for the index scores.

Construct Validity. Sheslow and Adams (1990) put forth several hypotheses to assess the construct validity of the WRAML. First, they proposed that the abilities assessed by the WRAML are developmental in nature and hypothesized a strong positive correlation between subtest scores and age. All correlations between subtest scores and age were positive and significant, ranging from .06 (Visual Learning for the nine and older age group) to .70 (Finger Windows across all ages). Second, they stated that the individual skills measured by the various subtests are related and thus should be positively correlated. Again, all correlations were positive and significant, ranging from .105 (Picture Memory and Number/Letter for the eight and younger age group) to .605 (Sentence Memory and Number/Letter for the nine and older age group). Third, they suggested that memory is not a singular ability and proposed that the subtests would form three factors, measuring verbal memory, visual memory, and learning. The results of the principal components analyses to assess this hypothesis are discussed in the following section. Fourth, they put forth that memory is related to general cognitive ability and hypothesized low to moderate correlations between WRAML scores and scores on standardized intelligence tests. The authors reported moderate correlations, as expected, between WRAML indexes and index scores on the Wechsler Intelligence Scale for Children-Revised. Finally, they predicted that memory, being related to academic achievement, would evidence low to moderate correlations between WRAML scores and scores on standardized achievement tests. Moderate correlations were found between WRAML index scores and scores on the Wide Range Achievement Test-Revised.

Original Index Structure. As mentioned above, Sheslow and Adams (1990) hypothesized that memory is a multifactorial construct and tested that assumption by subjecting the standardization data to principle components analyses with varimax rotations. They predicted that three components--Verbal Memory, Visual Memory, and Learning--would emerge. The authors analyzed the data in two age groups--eight years and younger and nine years and older--and determined that for each group a three-component solution was optimal (see Appendixes B and C). Although the authors describe three "distinct factors [sic] . . . [that] conformed generally to the verbal, visual, and learning divisions theorized" (Sheslow and Adams, 1990, p.93), the variable loadings were less conclusive, particularly for Story Memory and Visual Memory for all ages and Finger Windows for those children nine and older. These subtests were chosen for their respective indexes despite higher loadings on other components "because of the logical consistency offered" (p. 93). To their credit, Sheslow and Adams (1990) state that their decision was made on a theoretical rather than statistical basis and "further research could change this decision" (p. 93).

Principal Components and Factor Analytic Studies. Several researchers have criticized the original index structure and have attempted to identify clinically meaningful and statistically sound alternatives. The determination of the authors to retain their hypothesized structure despite the disconfirming results of the principal components analysis is difficult to defend, especially given that the structure suggests a meaningful alternate interpretation. If the subtests were placed on the index on which they received the highest weights, the visual-verbal distinction remains, the subtests from the Learning index fall back onto their modality-based components, and an index requiring rote memory or attention emerges. The resulting structure corresponds well to that of the most popular measure of memory in adults, the Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987). On the WMS-R, subtests that involve multiple learning trials cluster with other tests using the same (visual versus verbal) modality, while tests requiring short-term rote memory form an Attention/Concentration index. The only drawback for such a solution for the WRAML is the developmental mobility of the Finger Windows subtests. For the younger age group Finger Windows weighted most significantly on the visual component, while for the older group it received its highest weight on the rote memory or attention component.

Gioia (1991) used the published intercorrelation matrices from the original standardization sample to perform a series of principal factor analyses with varimax rotations. Initial analyses showed that a four-factor solution best fit the younger group's scores (see Appendix D), while a three-factor solution was most appropriate for the older group (see Appendix E). However, the interpretability of these factors is limited by the small size of some factors and the large, heterogeneous nature of others. For instance, the four factors identified for the younger age group can be best described as Nonverbal Memory, Verbal Span, and Mixed Verbal/Nonverbal Memory, and an additional factor containing only Sound Symbol. One subtest, Design Memory, loaded significantly on two factors. The three factors identified for the older group include Mixed Verbal/Nonverbal Memory, Verbal Span, and Verbal Memory, with two subtests--Verbal Learning and Sentence Memory--having salient loadings on two factors.

To examine the stability of the factor structures, however, Gioia (1991) computed the two, three, and four factor solutions for both age groups. The three factor solutions were compared with those identified through the principal components analyses by Sheslow and Adams (1990), and no support was found for the original structure. Furthermore, very little stability was found between different solutions.

In 1998, Gioia extended these analyses to include hierarchical factor analyses with orthogonal and oblique rotations to explore further the underlying factor structure of the WRAML for the two age groups (see Appendixes F and G). Both analyses revealed a strong General Memory factor at the second level on which all subtests loaded significantly and three weaker, first-order factors. The contents of the three factors, however, differed for the two age groups. For the younger group, the first factor was a weak Verbal Memory factor consisting only of Story Memory and

Verbal Learning. The second factor was a stronger Verbal Span factor, consisting of Sentence Memory and Number/Letter. The third factor was made only of Visual Learning. The remaining subtests--Picture Memory, Design Memory, Sound Symbol, and Verbal Learning--loaded significantly only on the General Memory factor. For the older age group, the first factor was a strong Visual Memory factor on which three tests--Picture Memory, Design Memory, and Visual Learning--loaded significantly. The second factor was the same Verbal Span combination of Sentence Memory and Number/Letter found in the younger group. The third factor consisted only of Story Memory. Three subtests--Sound Symbol, Verbal Learning, and Finger Windows--failed to load on any of the first-order factors. Because of the inconsistency between age groups and the failure of many subtests to load on first-order factors, Gioia (1998) concluded that, although he found no support for the original structure, no other factor solutions added much, if any, practical interpretive power. He recommends that scores be interpreted primarily on the individual subtest level, and secondarily in these clusters.

Wasserman and Cambias (1992) conducted an exploratory principal components analysis with varimax rotation, using the original standardization data. Unlike Sheslow and Adams (1990), Wasserman and Cambias (1992) used objective, a priori criteria for the retention of a subtest on a given component. Using the same two age groups as the original authors, Wasserman and Cambias identified statistically sound but different three-component solutions, consisting of Visual Memory, Verbally-Mediated Memory, and Attention or Immediate Recall components, for each group (see Appendixes H and I). For both age groups, the Visual Memory component consisted of Picture Memory, Design Memory, Finger Windows, and Visual Learning. Likewise, the Attention or Immediate Recall component consistently included Finger Windows, Sentence Memory, and Number/Letter. However, the subtests making up the Verbally-Mediated Memory component differed between the age groups. For the younger group, only Verbal Learning, Story Memory, and Sound Symbol met the retention criteria, while for the older group, Sentence Memory and Visual Learning were also correlated with this component. Wasserman and Cambias could not satisfactorily explain either the developmental instability of this component or the loading of Visual Learning on a component that otherwise included only tests of Verbally-Mediated Memory. Therefore, while their components are statistically sound, their clinical interpretation is limited.

Aylward, Gioia, Verhulst, and Bell (1995) utilized pairwise principal factor analyses to identify a factor structure using scores from a sample of more than 300 children referred to a clinic due to poor academic performance. They found that a three-factor solution (see Appendix J) was optimal for all ages and accounted for 36 percent of the variance. The first factor contained tests of Visual Memory (Picture Memory, Design Memory, Finger Windows, and Visual Learning), the second factor was a Short-Term Verbal Memory factor (Sentence Memory, Number/Letter Memory), and the third factor was termed a Verbal Semantic/Strategic factor (Verbal Learning, Story Memory). Significant weaknesses of this structure include the fact that two factors contain only two subtests each and Sound Symbol fails to load significantly on any factor. Furthermore, the reliance on an exclusively clinical population limits the generalizability of the findings.

Phelps (1995) conducted an exploratory principal components factor analysis with varimax rotation using a sample of 115 children referred for various academic problems. The factor analysis resulted in three factors that appeared to reflect Attention/Concentration (Design Memory, Sentence Memory, Number/Letter), Visual Memory (Picture Memory, Finger Windows, Sound Symbol, Visual Learning), and Verbal Memory (Verbal Learning, Story Memory; see Appendix K). This structure accounted for more than 60 percent of the variance, and while Phelps emphasized the strength of the factors and minimized the overlap between them, the factors appear no more definitive than other proposed solutions. For example, Design Memory, Story Memory, Sound Symbol, and Visual Learning all received moderate to strong loadings on more than one factor. This structure is also limited by the relatively smaller size and clinical nature of the sample.

Dewey, Kaplan, and Crawford (1997) found further evidence of an Attention/Concentration factor amid some complicated factor structures when they conducted separate factor analyses with three samples of children--a group with ADHD, a group with Reading Disorder (RD), and a control group. They identified different three-factor solutions for each group (see Appendixes L, M, and N), with those for the ADHD and RD groups being similar in overall structure, and differing greatly from the solution for the control group. For the group with ADHD, the factors included Verbal Memory (Story Memory, Sound Symbol, Verbal Learning, and Picture Memory), Visual Memory (Design Memory, Finger Windows, Visual Learning, and Picture Memory), and Verbal Attention/Concentration (Number/Letter and Sentence Memory). The loading of Picture Memory on both the Visual Memory and Verbal Memory factors blurs the clinical picture provided by this structure but could be due to the use of both verbal and visual processing during the task. For the RD group, the authors again found Verbal Memory (Story Memory and Sound Symbol) and Visual Memory (Picture Memory, Design Memory, Finger Windows, Visual Learning, and Verbal Learning) factors. However, while they identified an Attention/Concentration grouping, it was no longer limited to verbally mediated tests, but also included Finger Windows. A major drawback of this structure is the puzzling loading of Verbal Learning on the Visual Memory factor. In contrast to these family similar structures, the authors found quite a different solution for the control group. This solution included a large General Memory factor (Design Memory, Visual Learning, Picture Memory, Sound Symbol, Verbal Learning, and Story Memory) and two smaller factors--a Verbal Attention/Concentration factor (Number/Letter and Sentence Memory) and a Specific Verbal/Visual Memory factor (Finger Windows and Story Memory) that appeared related to attention and concentration. The clinical utility of this structure is questionable due to the inclusive nature of the first factor, the ambiguous construct underlying the third, and the inexplicably *negative* loading of one test (Story Memory) on the third factor.

Burton et al. (1996) conducted a study to sort out the confusion surrounding the various proposed structures for the WRAML. These researchers used the original standardization sample to conduct structural equation modeling of nine proposed factor structures. Among the nine models included in the initial analyses were a General Memory only solution; a General Memory and Learning model; a General Memory and Attention structure; a Verbal and Nonverbal Memory solution; the original Visual Memory, Verbal Memory, and Learning Indexes; and four Verbal Memory, Nonverbal Memory, and Attention models. These last four solutions differed by having the Attention factor consist of all possible two and three test combinations of Sentence Memory, Finger Windows, and Number/Letter, the subtests most often placed on such factors. Burton et al. (1996) found no supporting evidence for the Learning Index proposed by the Sheslow and Adams (1990). In fact, the best solution consisted of Verbal Memory, Nonverbal Memory, and an Attention factor that included Sentence Memory and Number/Letter.

Burton et al. (1996) followed up their initial analysis by modifying the most successful solution. Some authors have found that Finger Windows loaded most heavily on Nonverbal Memory factors, while others have placed it on Rote Memory or Attention factors. To investigate the possibility that Finger Windows is a multifactorial test, Burton et al. (1996) conducted a post hoc analysis of a tenth solution that placed Finger Windows on both the Nonverbal Memory and Attention factors. This structure (see Appendix O) was a significant improvement over all other models, including the model from which it was adapted. Additional analyses showed that this factor solution was valid for both the younger (eight and younger) and older (nine and older) age groups. In addition to being statistically sound, this solution is also clinically meaningful and interpretable.

Research on the WRAML with ADHD Populations

Very little research has compared the performance of children with and without ADHD on the WRAML, and the results from those studies are often contradictory. Five studies were found that compared the performance of children with and without ADHD on all or part of the WRAML. To ease comparison, the results are presented in Table 1. Adams et al. (1993) found that non-learning disordered children with ADHD scored lower than children without ADHD on Sentence Memory, Number/Letter, Design Memory, Finger Windows, and Sound Symbol. In addition, they found that the group with ADHD scored higher than the control group on Picture Memory. When comparing groups using the published index scores, they found significant differences on the Verbal, Visual, and General Memory Indexes. No difference was found on the Learning Index. A discriminant function analysis found that a function employing Finger Windows, Number/Letter, Picture Memory, Sound Symbol, and Design Memory (but not Sentence Memory) correctly classified 84 percent of the control subjects and 76 percent of the subjects with ADHD.

Mealer et al. (1996) compared 20 boys with ADHD to 20 psychiatric control subjects using the WISC-III and WRAML. They found that the ADHD group scored lower on the WRAML Finger Windows and Verbal Learning subtests, with differences approaching significance on the Sound Symbol and Visual Learning subtests. In addition, the ADHD group scored lower on the Visual Memory, Learning, and General Memory Indexes, with the difference on the Verbal Memory Index approaching significance. A discriminant function analysis using the nine WRAML subtests correctly classified 80 percent of the subjects in the ADHD group and 90 percent of subjects in the control group. While the authors state that the groups did not differ on estimates of cognitive functioning, a weakness of this study is the authors' failure to address issues of academic achievement or learning ability.

Phelps (1996) conducted a discriminative validity study of the WRAML, comparing children with ADHD or Reading Disorder (RD) to children referred to a clinic for other reasons. Using the four published WRAML indexes, Phelps (1996) found no significant differences between the children with ADHD, RD, or another diagnosis. A discriminant function analysis was conducted using seven WISC-III factors, three broad Woodcock-Johnson--Revised factors, and the WRAML indexes. The only WRAML index retained in the function was the Verbal Memory Index. Although the function accounted for more than 85 percent of the variance, it correctly classified only 50 percent of the subjects with ADHD. This study showed that the published WRAML indexes do not significantly differentiate children with ADHD from children with RD or other diagnoses. However, these results may reflect the questionable validity of the published indexes. Furthermore, the study did not include a nonclinical control group.

Some studies have used selected WRAML subtests as part of a larger assessment battery. Cahn and Marcotte (1995) administered the Story Memory subtest to a group of 57 children with ADHD and found that the children showed no deficit in their performance on this subtest. Seidman et al. (1995) compared children with and without ADHD on a neuropsychological battery and found significant differences on several tests, including the Verbal Learning subtest of the WRAML. However, when the group with ADHD, regardless of comorbidity, was subdivided based on the presence or absence of a family history the disorder, only the group with a family history continued to differ significantly from the control group. Furthermore, only the group with a family history of ADHD remained deviant from the control group after statistically controlling for comorbid learning disorder, anxiety, depression, or conduct disorder. The authors suggested that a family history of ADHD indicates a specific subtype of ADHD characterized by more severe neuropsychological impairment.

Overall, these studies appear to suggest that children with ADHD score differently on some, but not all, of the WRAML subtests, although it is unclear how much of this effect is the result of possible comorbid learning problems. Only one of the two studies that found significant differences between ADHD and non-ADHD subjects using all WRAML subtests addressed the issue of academic achievement (Adams et al., 1993). Conversely, the studies that most effectively addressed issues of academic achievement (Phelps, 1996; Cahn & Marcotte, 1995; Seidman et al., 1995) found no significant differences but relied on either a single subtest or the questionable original indexes. Furthermore, little consistency can be found across the results of these studies. All three studies involving the Story Memory subtest (Adams et al., 1993; Mealer et al., 1996; Cahn & Marcotte, 1995) failed to find significant differences between children with and without ADHD, and the two studies that included the Finger Windows and Sound Symbol subtests (Adams et al., 1993; Mealer et al., 1996) found differences that at least approached significance. The results for all other subtests and indexes, however, were mixed. Additionally, of the two studies that entered the subtest scores into a discriminant analysis (Adams et al., 1993; Mealer et al., 1996), both found the Finger Windows subtest to be a significant discriminator, but other subtests loading into the function differed.

Table 1
Results of Studies Utilizing the WRAML with ADHD Populations

Variable	Adams et al. (1993)	Mealer et al. (1996)	Phelps (1996)	Cahn & Marcotte (1995)	Seidman et al. (1995)
Picture Memory	<.01	(ns)			
Design Memory	<.01	(ns)			
Verbal Learning	(ns)	.008			<.05* / (ns)**
Story Memory	(ns)	(ns)		(ns)	
Finger Windows	<.01	.001			
Sound Symbol	<.01	.062			
Sentence Memory	<.02	(ns)			
Visual Learning	(ns)	.077			
Number/Letter	<.01	(ns)			
Verbal Memory Index	<.01	.006	(ns)		
Visual Memory Index	<.03	.088	(ns)		
Learning Index	(ns)	.018	(ns)		
General Memory Index	<.01	.004	(ns)		

* All ADHD vs. Control
**After controlling for family history, learning disorder, anxiety, depression, and conduct disorder

Accuracy in Clinical Diagnosis

The search for assessment methods that accurately differentiate various clinical groups is fraught with many challenges. One of the most daunting of these challenges was described by Meehl and Rosen (1955) when they wrote, "A psychometric device, to be efficient, must make possible a greater number of correct decisions than could be made in terms of the base rates alone" (p.194). This is more difficult than it first seems. Base rates are "the frequency with which events or conditions occur in the population of interest" (Faust, 1986, p. 589), and they can greatly affect the accuracy of clinical decisions.

Prevalence rates for ADHD in children vary greatly but are generally around 5 percent (American Psychiatric Association, 1994). Therefore, if Dr. Doolittle were to utilize only base rate information, he could theoretically diagnose no one as having ADHD and be correct in 95 percent of cases. It is important to note, however, that base rates are population-specific and are not generalizable to other groups. Unless Dr. Doolittle is able select his clientele randomly from the entire population of school-aged children, employing the 5 percent base rate would be inaccurate. He would need, instead, to know the base rate of ADHD in children referred for the type of services he provides (e.g., psychotherapy or other interventions for behavioral, academic, or social problems, etc.). This rate could vary greatly depending upon the referral practices in his area, but would certainly be greater than 5 percent. As a result, simply utilizing base rates will no longer lead to such a high degree of accuracy, so the doctor must go in search of an assessment measure which performs better than "playing the odds." However, he must not forget the problem of base rates, for just as they affect the accuracy of his blind diagnoses, they will also affect the accuracy of decisions based on objective, standardized measures.

The potential severity of the base rate problem is illustrated by a variation on an analogy presented by Meehl and Rosen (1955). Consider two children, one with

ADHD and one without the disorder. These children can be represented by two containers, a golden urn and a wooden pail, respectively. Both children are subjected to an assessment measure, the results of which are represented by 100 colored stones placed within each vessel. This assessment measure has a valid positive rate of 80 percent, indicating that 80 percent of children with ADHD score below a certain level on the test. Therefore, imagine that 80 of the stones within the golden urn are red. However, the test has a false positive rate of 25 percent, so that 25 percent of children without ADHD also score below the cutoff. Thus, 25 of the stones in the wooden pail are red. A person is blindfolded, randomly selects a container, and draws out a stone, which happens to be red. Based on this single red stone, the person is asked to guess from which vessel it was selected. The person logically guesses that he chose from the urn: After all, 80 percent of the stones in the urn were red, whereas this was true of only 25 percent of the stones in the wooden pail. This is similar to the findings in research studies in which clinical and control groups are matched in size and, thus, a person is just as likely to have chosen from the golden urn as from the wooden pail. However, in the "real world," there are simply not as many golden urns as wooden pails Therefore, although golden urns each contain 80 percent red stones and wooden pails contain only 25 percent red stones, if a container is selected randomly from the population, only one time in twenty will it be a golden urn. This selection bias dilutes the fact that the urns contain more red stones than do the wooden pails.

In probability theory, accounting for base rates in the computation of likelihoods is called "Bayes' Theorem." Given k possible conditions (i.e., diagnoses or lack thereof) in the population, each has the antecedent probability or base rate of $P_1, P_2, \ldots, P_k$ and the probability of occurring under a given circumstance (i.e., a low test score) of $p_1, p_2, \ldots, p_k$. To figure out the probability of a specific condition, P_j (i.e., probability ADHD is present), given the presence of the stated circumstance (i.e., a low test score), the following formula is used:

$$P_{j(0)} = \frac{P_j \, p_j}{\sum_{i=1}^{k} P_i \, p_i}$$

When applied to a dichotomous decision (i.e., ADHD or not), the formula can be rewritten as follows:

$$P_{(0)} = \frac{P \, p_1}{Pp_1 + Qp_2},$$

$P_{(0)}$	=	probability that a particular individual has ADHD
P	=	base rate of ADHD in the population
Q	=	base rate of non-ADHD in the population
P + Q	=	1
p_1	=	proportion of ADHD individuals identified by the test (valid positive rate of the test)
p_2	=	proportion of nonADHD individuals misidentified as ADHD by the test (false positive rate of the test)

Based on the hypothetical numbers put forth in the golden urn example described above, the following values are substituted:

$$P_{1(b)} = \frac{(.05)(.80)}{(.05)(.80) + (.95)(.25)} = 0.144.$$

Therefore, if the base rate of ADHD in the population is 5 percent and a test exists on which 80 percent of children with ADHD and 25 percent of children without ADHD score below a given level, then the probability that a child has ADHD given that he or she scores below that cutting point, is only slightly higher than 14 percent! In fact, in order for this probability to exceed 50 percent, the ratio of individuals with the disorder to those without must be greater than the ratio of false positives to valid positives on the assessment measure (Meehl & Rosen, 1955). Therefore, given that the ratio of individuals with ADHD to those without is estimated to be 5:95, a test with an 80 percent valid positive rate would have to have a false positive rate less than 5 percent.

It is important to remember, as mentioned above, that base rates are population-specific and are not generalizable to other groups. Unless someone is planning to test the entire population of children, employing the 5 percent base rate would be inaccurate. Using the base rate of ADHD in the population from which the subjects were selected would only be appropriate (e.g., children enrolled in a particular school district, children referred to school committees for academic problems, children referred to mental health clinics for behavior problems, etc.). If, for instance, the base rate in the referred population were 50 percent, the probability that a child has the disorder given that he or she scored below the demarcation line on the hypothetical test would be computed by dividing the valid positive rate by the sum of the valid and false positive rates,

$$\frac{.80}{.80 + .25} = .762.$$

This obviously results in a much more satisfactory outcome.

The above examples illustrate the importance of considering base rates in clinical decision making and when assessing the discriminative validity of an assessment measure.

<u>Summary</u>

As discussed above, although results are mixed, children with ADHD have been found to score significantly below children without ADHD on some, but not all, types of memory tasks. Differences are found most often on tasks requiring the exact, immediate recall of verbal stimuli (e.g., word lists, digit spans, exact sentences), especially when some manipulation of the data is required (e.g., grouping of words into groups, the rehearsal of numerical sequences or long sentences). In contrast, differences are rarely, if ever, found on tasks that demand the general or "gist" recall or simple recognition of verbal or visual-spatial information (e.g., stories, complex figure tests, spatial memory). By taking advantage of this pattern of scores, a battery of tests assessing these skills may be helpful in the assessment and understanding of ADHD.

The WRAML might be a good candidate for this type of assessment. It is a well-standardized measure consisting of a variety of memory tasks, including several that closely resemble those on which children with ADHD have traditionally differed from their counterparts without ADHD. However, the current design of the WRAML and its composite scores dilutes the power of those tests to identify such weaknesses by scattering them across poorly constructed indexes. Several alternative factor structures have been proposed. The most statistically sound and clinically meaningful structure, proposed by Burton et al. (1996), has the potential to improve the ability of the WRAML to identify children with significant attention problems. This structure groups potentially useful subtests together to form an Attention factor, while retaining the original Verbal-Visual dichotomy in a different arrangement. Preliminary research by Adams and his colleagues (1990) showed that children with ADHD score significantly below children without ADHD on the subtests that form this Attention factor. However, the discriminative validity of this factor structure has not been tested. The present study assessed the ability of the individual WRAML subtests, the original index structure, and the Burton et al. (1996) factor structure to differentiate children with and without ADHD.

Purposes

The purposes of this study were first, to find out if children with ADHD score differently from children without ADHD on the WRAML, after controlling for differences in cognitive functioning and academic achievement, and second, to learn if scores on the WRAML subtests, indexes, or factors can be used successfully to identify children with ADHD.

Purpose 1: Identify Group Differences. Test scores were examined for group differences on WRAML subtests, indexes, and alternative (Burton et al., 1996) factors. It was predicted that children with ADHD would score lower than children without ADHD on select subtests of the WRAML. Specifically, the greatest differences were expected on Finger Windows, Number/Letter, and Sentence Memory, as these subtests require the accurate recall of specific details or sequences of stimuli. It was also expected that the children with ADHD would receive lower scores on the original Verbal Memory and General Memory Indexes, as these measures rely heavily on the rote memory or attention-based subtests. Scores were not predicted to differ on the original Visual Memory or Learning Indexes. Using the Burton et al. (1996) factors, it was hypothesized that a significant difference would be found between the children with and without ADHD only on the Attention factor.

Purpose 2: Assess Classification Accuracy. The ability of the individual subtests, original indexes, and alternative factors to classify subjects as having ADHD or not was assessed. It was expected that the discriminant function using the subtest scores would include those tests included on the Burton et al. (1996) Attention factor--Number/Letter, Sentence Memory, and Finger Windows. Furthermore, it was predicted that a discriminant function using the Burton et al. (1996) factors would correctly classify more subjects than the function using the original indexes, which would not exceed chance.

MATERIALS AND METHODS

Subjects

One hundred and nineteen children enrolled in the first through seventh grade were recruited through notices in physicians' offices, psychology clinics, schools, support group meetings and newsletters, and through students enrolled in undergraduate psychology courses. Signed written consent for voluntary participation was obtained from each parent and child participating in the study. The form letter and consent form given to parents are presented in Appendixes P and Q, respectively. A separate consent form, granting permission to obtain data from the child's school (see Appendix R), was also obtained from each parent.

Measures

Demographic Questionnaire. A brief demographic questionnaire (see Appendix S) was included in each packet of parent questionnaires to obtain information regarding racial identity, household composition, and socioeconomic status. The Hollingshead four-factor index (Hollingshead, 1975) was used to estimate socioeconomic status.

Rating Scale for Research (RSR). The RSR (see Appendix T) provided a criterion-based measure of problems with inattention/disorganization and hyperactivity/impulsivity. The RSR consists of the DSM-IV diagnostic criteria for ADHD on which the parent rates his or her child on a scale from zero "(not at all") to three ("very much"). Items rated as two ("pretty much") or three ("very much") are considered endorsed. The number of endorsed criteria of each type--primarily inattentive and primarily hyperactive/impulsive--is summed. This questionnaire is virtually identical (with minor differences in wording and format) to two measures, the ADHD Rating Scale-IV (DuPaul, Reid, Power, & Anastopoulos, 1998) and the ADHD portion of the Disruptive Behavior Rating Scale (Barkley & Murphy, 1998), which were published after the inception of the present study. Barkley (1998) recommends the use of the Disruptive Behavior Rating Scale as a criterion-based measure in the manner that the RSR was utilized in this study. DuPaul and his colleagues, in contrast, have published numerous articles on the reliability, validity, and normative sampling of the ADHD Rating Scale-IV (e.g., DuPaul, Power, McGoey, Ikeda, & Anastopoulos, 1998; DuPaul, Anastopoulos, et al., 1998; Power, Andrews, et al., 1998; Power, Doherty, et al., 1998).

Achenbach Child Behavior Checklist (CBCL; Achenbach, 1991). The CBCL is a widely used, well-standardized, norm-referenced measure of behavior problems in children aged four to 18. It produces eight factor scores: Withdrawn, Anxious/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Aggressive Behavior, and Delinquent Behavior. The CBCL in its various forms has been shown to have sufficient reliability (e.g., Achenbach & Edelbrock, 1979) and to discriminate children with and without ADHD (e.g., Edelbrock & Costello, 1988; Biederman et al., 1993).

Wide Range Assessment of Memory and Learning (WRAML; Sheslow & Adams, 1990). The WRAML is described in detail above.

Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990). The K-BIT is an individually administered test of intelligence for individuals between four and 90 years of age. It consists of Vocabulary and Matrices sections, which assess verbal and nonverbal intelligence, respectively. The Vocabulary section is made up of Expressive Vocabulary and Definitions sections. The Expressive Vocabulary section requires the individual to identify pictures of common objects by name. The Definitions section requires the subject to use verbal cues and partial spellings to identify target words. The nonverbal Matrices section involves selecting from available response choices a picture or design to complete illustrated analogies or abstract matrices. The K-BIT is a well-normed test that can be administered quickly by trained nonpsychologists. It has been shown to have adequate reliability and validity. K-BIT IQ Composites correlate highly (.80) with WISC-R Full Scale scores (Kaufman & Kaufman, 1990).

Child Behavior Checklist--Teacher Report Form (TRF; Edelbrock & Achenbach, 1984). The TRF is a well-normed measure that parallels the CBCL and contains several items that assess classroom behavior and performance specifically. The TRF has sufficient reliability (Edelbrock & Achenbach, 1984), correlates well with other measures of classroom behavior problems (e.g., Reed & Edelbrock, 1983; Edelbrock & Reed, 1984), and differentiates children with ADHD from other clinic-referred children (e.g., Edelbrock, Costello, & Kessler, 1984; Kazdin, Esveldt-Dawson, & Loar, 1984).

Procedure

This study was approved by the Louisiana State University and Agricultural and Mechanical College Institutional Review Board for Research with Human Subjects. A parent was asked to complete the consent forms, demographic questionnaire, the RSR, and the CBCL. The child's teacher was then contacted by form letter (see Appendix U) and asked to complete the RSR and the TRF. During this time, a copy of the child's most recent standardized test results was obtained by facsimile transmission from the school. For schools without facsimile machines, the request was made by mail (see Appendix V). To avoid the confounding effects of comorbid Learning Disorder, children with overall reading or overall math achievement scores below the 17th national percentile (one standard deviation) were excluded from the study.

After all questionnaires and test results were obtained, the child's learning and memory assessment was scheduled. During the standardized testing session, the child was administered the WRAML followed by the K-BIT. Research testing was completed during one approximately 60 to 90-minute test session. All WRAML administrations were conducted by trained graduate students or licensed clinical psychologists familiar with administration of the WRAML and other standardized tests. K-BIT administrations were conducted by trained graduate or undergraduate students. Subjects with estimated IQs at or below 85 or major sensorimotor impairments (e.g., paralysis, blindness, deafness) were excluded from the study. Parents were instructed not to administer medications such as Ritalin, Dexedrine, or Adderall on the day of testing before their child's appointment. Due to the need to verify that no subjects were under the effects of medication at the time of testing, remaining completely blind to the group status of all subjects was impossible for the experimenter.

The data for some subjects with ADHD (n = 22) were obtained from archival sources. In such cases, achievement scores were taken from individual tests, such as the Wechsler Individual Achievement Test (WIAT; Psychological Corporation, 1992) or Woodcock-Johnson Tests of Achievement--Revised (WJ-R; Woodcock & Johnson, 1990), and intellectual functioning was estimated using the Wechsler Intelligence Scale for Children--Third Edition (WISC-III; Wechsler, 1991). It was ascertained that these children were not under the effects of medication at the time of testing.

Attention-Deficit/Hyperactivity Disorder Group

The ADHD group consisted of children exhibiting problems with inattention and/or hyperactivity as reported by both a parent and a teacher on both criterion-referenced and norm-referenced measures. These were children about whom a parent and teacher both endorsed six or more items from either or both the Inattentive-Disorganized and Hyperactive-Impulsive section of the RSR, thus ensuring that the child met diagnostic criteria for ADHD. Power, Andrews, and colleagues (1998), in researching the ADHD Rating Scale-IV (DuPaul, Reid, et al., 1998), found that while having the form completed by either the parent or teacher was generally sufficient for ruling out the presence of ADHD, acquiring ratings from both sources maximized diagnostic accuracy. For the portion of the ADHD group obtained from archival sources, the RSR was not available, and data from structured or semi-structured clinical interviews with parents and teachers were substituted.

To enhance group definition further, both the parent and teacher must have rated the child at least one and a half standard deviations above the mean (T score of 65 or greater) on the Attention Problems (or Hyperactivity) factor of the CBCL and TRF, respectively. This cutoff is recommended by the author of the CBCL (Achenbach, 1991) and has been found to provide the most continuity between current and former versions of the CBCL still used in some clinics (Anastopoulos, 1993). Although some researchers (e.g., Barkley, 1990) have recommended a cutoff of 70, several studies (e.g., Steingard, Biederman, Doyle, & Sprich-Buckminster, 1992; Shekim et al., 1986; Biederman et al., 1993) have shown this requirement to exclude significant numbers of subjects diagnosed with ADHD through other means.

An exception to the requirement of elevated teacher ratings was made for children who had been previously diagnosed as having ADHD and were currently taking medication for the disorder during school hours. For these children, significantly elevated ratings from a parent were sufficient if the teacher had witnessed only the child's behavior under the effects of medication. An attempt was made to obtain copies of these children's original evaluations to ascertain that their diagnoses were based on standardized behavioral data. Thirty-two subjects received elevated ratings from a parent and a teacher on both measures. The remaining 25 subjects were rated as significantly elevated only by a parent but were currently taking medication during school hours. Of this group, adequate data to verify the diagnosis were obtained for nine, but such information was not available for the remaining 16. To make certain that this medicated group for whom past data were not available did not differ from the remaining ADHD subjects, the two groups were compared on demographic information, parental measures of inattention and hyperactivity, estimated intellectual functioning, and academic achievement scores. The results are presented in Table 2.

To adjust for multiple comparisons, only differences with probabilities less than 1 percent were considered significant. Only estimated nonverbal IQ (PIQ) reached significance ($p = .01$), although estimated Full Scale IQ (IQ) and Reading

Achievement percentiles approached significance. For all three variables, the medicated group for whom no records were available scored above the children who met the criteria based on current ratings or available records.

Table 2
Means and Standard Deviations on Key Variables: Verified and Unverified ADHD Groups

	Unverified ADHD (n = 16)		Verified ADHD (n = 41)				
Variable	M	SD	M	SD	χ^2	T	p
Gender	$\underline{n}$		$\underline{n}$		.21		.74
Female	3		10				
Male	13		31				
Race	$\underline{n}$		$\underline{n}$		.87		.64
Caucasian	15		39				
African-Amer.	1		1				
Asian	0		0				
Age	9.88	1.63	9.17	1.70		-1.42	.16
Grade Level	$\underline{n}$		$\underline{n}$		8.21		.27
1	0		2				
2	0		6				
3	4		9				
4	3		11				
5	4		7				
6	2		5				
7	3		1				
SES	39.37	19.22	32.78	17.27		-1.04	.31
VIQ	109.94	11.88	105.90	9.98		-1.30	.20
PIQ	113.56	9.10	106.44	9.01		-2.67	.01
IQ	113.00	9.96	106.68	9.78		-2.18	.03
Reading	75.00	24.14	59.32	22.88		-2.29	.02
Math	69.31	26.83	62.54	25.24		-0.90	.37
Parent RSR (Inattentive)	7.25	2.05	7.84	1.50		0.98	.33
Parent RSR (Hyperactive)	5.75	2.98	5.95	2.97		.20	.85
CBCL (Attention Problems)	70.00	5.07	73.12	6.48		1.62	.11

There are several possible explanations for the differences in cognitive and achievement test scores. First, they could be due to chance, the result of computing multiple comparisons. However, this is unlikely given that the three variables measure related cognitive skills and the direction of the difference was consistent. Second, the group for whom no records were available could exhibit a less severe form of ADHD. As a result, they may have been diagnosed in a physician's office and, with fewer associated problems, had less contact with mental health professionals, who may be more likely to keep the types of documentation needed for their diagnosis to be verified for this study. However, this is speculative, and the failure to find significant differences on parental measures of inattention or hyperactivity casts doubt on the supposition that these children suffer from a less severe form of ADHD. Third, these children might be better responders to medication, resulting in teacher ratings within the normal range while parent ratings remain high. This better response to medication could result in better school performance, which could, in turn, lead to higher scores on standardized tests of cognitive ability and achievement. This is considered the most likely explanation.

To assure that parents were aware of their children's problems with inattention and/or hyperactivity, the parents of children placed in the ADHD group were informed that, based on the information gathered for this study, their children appeared to have elevated levels of inattention and/or hyperactivity and might benefit from further evaluation and possible intervention. Several referral sources were provided to interested parents. This notice was not given to parents who either reported diagnosed attention deficits on the demographic information form or were referred to the study from a diagnosing agency with the indication that an assessment had been or was being conducted.

Control Group

Subjects in the control group were children for whom a parent and a teacher reported problems with inattention or hyperactivity on neither the criterion-based nor norm-referenced measures. Specifically, neither the parent nor the teacher endorsed more than three items from either section of the RSR. In addition, neither the parent nor the teacher rated the child more than one standard deviation above the mean (T score no greater than 60) on the Attention Problems subscale of the CBCL. The groups were matched as closely as possible on key demographic variables (e.g., age, grade level, gender, race, SES), estimated intellectual ability, and academic achievement level.

RESULTS

Demographic Information

The ADHD and control groups were compared on key demographic variables, including age, grade level, gender, race, and estimated socioeconomic status. The results are presented in Table 3. After adjusting for multiple comparisons ($\alpha = .01$), the only significant difference was found in the gender composition of the groups. The control group was fairly evenly divided (27 males, 35 females), while the ADHD group was predominantly male (44 males, 13 females). The gender ratio of 3.4:1 in the ADHD group is consistent with that results reported elsewhere (e.g., Lalonde, Turgay, & Hudson, 1998; Szatmari, Offord, & Boyle, 1989; American Psychiatric Association, 1994). However, due to the discrepancies between groups, gender was entered as a covariate on all comparisons, except where noted.

Cognitive and Academic Functioning

To ensure that differences found in WRAML scores between the groups did not result from differences in intellectual functioning or academic achievement, the two groups were compared on verbal (VIQ), nonverbal (PIQ), and overall intelligence (IQ; standard scores), and on academic achievement in reading and math (national percentile ratings). The results are presented in Table 4. After adjusting for multiple comparisons ($\alpha = .01$), only math achievement percentiles differed significantly between the groups, although reading achievement percentiles approached significance. As a result, reading and math achievement percentiles were entered as covariates on all group comparisons, except where noted. Contrary to past research findings (e.g., Faraone et al., 1993; Biederman et al., 1996), the groups did not differ on estimated cognitive ability.

Table 3
Means and Standard Deviations on Demographic Variables: ADHD and Control Groups

	ADHD ($n = 57$)		Control ($n = 62$)				
Variable	*M*	*SD*	*M*	*SD*	X^2	*T*	*p*
Gender	*n*		*n*		13.97		.0002
Female	13		35				
Male	44		27				
Race	*n*		*n*		2.09		.72
Caucasian	54		55				
African-American	2		5				
Asian	1		1				
American Indian	0		1				
Grade Level	*n*		*n*		6.13		.44
1	2		4				
2	6		7				
3	13		7				
4	14		18				
5	11		13				
6	7		12				
7	4		1				
Age	9.37	1.70	9.29	1.71		-0.25	.80
SES	36.42	18.10	36.74	14.21		0.09	.93

Table 4
Means and Standard Deviations on IQ and Achievement: ADHD and Control Groups

	ADHD ($n = 57$)		Control ($n = 62$)			
Variable	*M*	*SD*	*M*	*SD*	*T*	*p*
VIQ	107.04	10.60	105.92	10.42	-0.58	.56
PIQ	108.44	9.52	110.72	11.64	1.18	.24
IQ	108.46	10.15	109.19	9.66	0.40	.69
Reading PR	63.72	24.09	73.14	21.12	2.26	.02
Math PR	64.44	25.64	76.39	20.57	2.79	.006

WRAML Subtests, Original Indexes, and Proposed Factors

To find if children with and without ADHD score differently on the WRAML, the two groups' scores were compared in three forms--the nine individual subtests, the four original indexes, and the three proposed (Burton et al., 1996) factors. The means and standard deviations of the two groups on these measures are presented in Table 5.

Table 5
Means and Standard Deviations on WRAML Variables: ADHD and Control Groups

	ADHD ($n = 57$)		Control ($n = 62$)	
SUBTESTS	*M*	*SD*	*M*	*SD*
Picture Memory	8.91	2.25	8.06	2.44
Design Memory	8.98	2.97	9.56	2.51
Verbal Learning	10.80	3.04	11.44	2.40
Story Memory	10.42	3.04	9.95	2.84
Finger Windows	8.47	2.53	9.66	2.37
Sound Symbol	10.37	2.76	10.24	3.07
Sentence Memory	10.30	2.70	10.22	2.71
Visual Learning	9.54	2.70	10.45	2.48
Number/Letter	8.23	2.11	9.03	2.34
ORIGINAL INDEXES				
Verbal Memory Index	97.54	13.47	98.24	11.83
Visual Memory Index	91.58	12.38	93.60	11.26
Learning Index	101.89	13.88	104.92	12.50
GENERAL MEMORY INDEX	96.28	12.57	98.77	10.64
PROPOSED FACTORS				
Verbal Memory	31.60	6.71	31.63	6.01
Visual Memory	35.91	6.74	37.74	6.10
Attention	27.00	5.47	28.92	5.32

In the analyses that follow, only differences with chance probabilities less than 1 percent ($\alpha = .01$) were considered significant, except where adjustments to multiple comparisons were otherwise made, as with the Tukey-Kramer adjusted post hoc analyses. To detect the significance of group differences on the subtest level, a two-way (group x test) MANCOVA was conducted on the nine WRAML subtests, with gender, math achievement, and reading achievement entered as covariates. The results are presented in Table 6.

Table 6
MANCOVA and ANCOVA Results for WRAML Variables

		Gender		Reading		Math		Group	
Variables	*df*	*F*	*p*	*F*	*p*	*F*	*p*	*F*	*p*
Subtests	9, 106	1.59	.13	1.84	.07	2.92	.004	1.80	.08
Indexes	3, 111	1.18	.32	3.11	.03	6.15	.0007	1.17	.32
GMI	4, 113	3.10	.08	7.02	.009	18.02	.0001	1.50	.22
Factors	3, 112	3.14	.03	3.38	.02	6.19	.0006	1.34	.25

Contrary to predictions, the comparison revealed that differences between the groups approached but did not reach significance, $F(9, 106) = 1.80, p = .08$. Furthermore, examination of Tukey-Kramer adjusted post hoc univariate analyses revealed that no group differences were significant. Examination of covariate effects revealed a significant effect only for math achievement, $F(9, 106) = 2.92, p = .004$, although the effect for reading achievement approached significance, $F(9, 106) = 1.84, p = .07$. This shows that children with and without ADHD did not score significantly differently on the nine WRAML subtests once the effects of academic achievement were taken into account. The results of analyses without taking into account academic achievement are discussed below.

To determine the statistical significance of differences on the Index scores, a two-way (group x index) MANCOVA was conducted on the original WRAML indexes, with gender, reading achievement, and math achievement again entered as covariates. The results are displayed in Table 6. As with the individual subtests and contrary to the hypothesis, no significant difference was found in the pattern of Index scores based on group membership. Examination of the covariates again revealed a nonsignificant effect for gender, a significant effect for math achievement, $F(3, 111) = 6.15$, $p = .0007$, and a near significant effect for reading achievement, $F(3, 111) = 3.11$, $p = .03$. As with the individual subtests, these results show that, after accounting for the effects of math and reading achievement on the pattern of WRAML index scores, the resulting differences between the scores of children with and without ADHD were not significant. Finally, an ANCOVA was used to compare the groups' scores on the General Memory Index, with gender, reading achievement, and math achievement entered as covariates. The results, presented in Table 6, revealed significant effects only for the covariates of reading achievement, $F(4, 113) = 7.02$, $p = .009$, and math achievement, $F(4, 113) = 18.02$, $p = .0001$, with no significant effect for the covariate of gender or the main effect of group membership. This indicates that, after controlling for the effect of academic achievement, the two groups did not differ significantly on the General Memory Index.

To begin examining the discriminative validity of the Burton et al. (1996) factor structure, a two-way (group x factor) MANCOVA was conducted on the sums of scaled scores for the proposed factors. Results are presented in Table 6. Again in contrast to prediction, the difference between groups was nonsignificant after controlling for the covariate effects of academic achievement. As with the comparisons described above, the effect of math achievement was statistically significant, $F(3, 112) = 6.19$, $p = .0006$, and the effect of reading achievement approached significance, $F(3, 112) = 3.38$, $p = .02$. However, unlike the other comparisons, the effect for gender also approached significance, $F(3, 112) = 3.14$, $p = .03$. Again, after the effects of academic achievement were taken into account, the remaining differences between the groups with and without

ADHD were not significant. The near significance of gender in this comparison is most plausibly explained as a statistical artifact resulting from conducting multiple comparisons. However, the possibility that the genders score differently across factors should be considered.

Barkley (1997) argues that by controlling for cognitive or achievement scores in comparisons of children with and without ADHD, researchers may unwittingly be factoring out part of the variable of interest (ADHD status). If the nature of ADHD leads individuals to score artificially low on measures of intellect or achievement, his assertion may have merit. Although the causal link between ADHD and scores on measures of cognitive ability and academic achievement is not clearly understood, several studies have found significant differences between individuals with and without the disorder on such measures (e.g., Faraone et al., 1993; Biederman et al., 1996). Until our understanding of this link improves, Barkley (1997) recommends that researchers who choose to control for such variations also present the results of comparisons without such statistical controls. Therefore, the comparisons described above were repeated without adjusting for the effects of covariates.

A two-way (group x subtest) MANOVA was conducted on the nine WRAML subtests, revealing a barely significant difference in the pattern of scores between groups, $F(9, 109) = 2.57$, $p = .01$. However, Tukey-Kramer adjusted post hoc univariate analyses revealed no significant difference between the groups on any WRAML subtest. These results are presented in Table 7. Furthermore, two-way (group x index) MANOVAs on the original WRAML indexes and the Burton et al. (1996) factors showed no significant difference in the patterns of scores between groups, as did an

ANOVA comparing the two groups on the General Memory Index. These results are provided in Table 8.

Table 7
MANOVA Results for WRAML Subtests

Variable	MANOVA *F* (9,109)/ Tukey-Kramer Post hoc *Q*	*p*
WRAML Subtests	2.57	.01
Picture Memory	2.75	.58
Design Memory	1.61	.97
Verbal Learning	1.76	.94
Story Memory	1.22	.99
Finger Windows	3.70	.19
Sound Symbol	0.31	1.00
Sentence Memory	0.20	1.00
Visual Learning	2.68	.62
Number/Letter	2.76	.58

In summary, comparisons of children with and without ADHD on the individual subtests, original indexes, and proposed (Burton et al., 1996) factors of the WRAML all indicate no significance differences between the groups even when the significant covariate of academic achievement is not taken into account.

Table 8
MANOVA and ANOVA Results for WRAML Indexes and Factors

Variables	*df*	MANOVA/ANOVA *F*	*p*
WRAML Indexes	3, 114	0.54	.66
WRAML GMI	1, 116	1.01	.32
WRAML Factors	3, 115	1.72	.17

Predictive Validity

Discriminant function analyses were conducted to examine the accuracy with which the WRAML subtests, indexes, and proposed factors classified the subjects into the appropriate ADHD or Control category. First, the nine WRAML subtests were entered into a backward stepwise discriminant function analysis. The results appear in Table 9.

Four subtests--Picture Memory, Finger Windows, Sentence Memory, and Number/Letter--were retained, and the resulting function significantly differentiated the two groups (Wilks' Lambda = 0.86, $F[4, 114] = 4.49$, $p = .002$). The relative contributions of the retained subtests were determined using the discriminant function-variable correlations, which despite statistical significance were quite low. As hypothesized, with the exception of Picture Memory, the retained subtests form the proposed Attention factor (Burton et al., 1996). However, despite this overlap and contrary to prediction, the discriminant function produced very poor classification rates. As presented in Table 10, the function correctly identified only 65 percent of each group, far below the rate achieved using base rates. In fact, if the classification rates of this function are adjusted to reflect the 5 percent prevalence of ADHD in the childhood population (as opposed to the near 50 percent prevalence in this study), 97 percent of the control subjects but only 9 percent of ADHD subjects would be correctly classified.

Second, a backward stepwise discriminant function analysis was conducted using the original WRAML Indexes. However, all three indexes were removed from the function, a result consistent with hypotheses. A discriminant function analysis forcing the inclusion of the three indexes was a very poor indicator of group membership (see

Table 11), correctly identifying only 55 percent of the subjects (ADHD, 39 percent; Control, 70 percent). As predicted, these results barely exceed chance levels and fall well below the percentages obtained utilizing base rates.

Table 9
Results of Discriminant Function Analysis Using WRAML Subtests

Variable	Partial R^2	F	p
Finger Windows	.06	7.82	.006
Picture Memory	.05	5.59	.02
Number/Letter	.03	4.09	.04
Sentence Memory	.03	3.36	.07
Design Memory	.02	2.10	.15
Story Memory	.01	1.70	.20
Verbal Learning	.01	.83	.36
Visual Learning	.005	.54	.46
Sound Symbol	.0004	.05	.83

Table 10
Classification Results of Discriminant Function Analysis Using WRAML Subtests

		Predicted Group Membership			
		ADHD		Control	
Actual Group	N	n	%	n	%
ADHD	57	37	64.9	20	35.1
Control	62	22	35.5	40	64.5

Note. Percentage of grouped cases correctly classified = 64.7%. Prior probabilities set at .5 for each group.

Finally, an analysis using the proposed Burton et al. (1996) factors was conducted, and the results are presented in Table 12.

Table 11
Classification Results of Discriminant Function Analysis Using WRAML Indexes

		Predicted Group Membership			
		ADHD		Control	
Actual Group	*N*	*n*	%	*n*	%
ADHD	57	22	38.6	35	61.4
Control	62	19	30.0	43	70.0

Note. Percentage of grouped cases correctly classified = 54.6%. Prior probabilities set at .5 for each group.

Table 12
Results of Discriminant Function Analysis Using Proposed WRAML Factors

Variable	Partial R^2	F	p
Attention	.03	3.76	.05
Verbal Memory	.006	0.75	.39
Visual Memory	.006	0.67	.41

Consistent with hypothesis, the Verbal Memory and Visual Memory factors were removed from the function, leaving only the Attention factor. However, contrary to prediction, the ability of this function to differentiate the two groups only approached significance (Wilks' Lambda = 0.97, $F[1, 117] = 3.76$, $p = .05$). As with the function involving the individual subtests, the variable-function correlation was statistically significant but small in magnitude. Furthermore, although this function is theoretically sound, it was a poor predictor of group membership. As seen in Table 13, this function correctly identified only 56 percent of each group, which, in contrast with the expected findings, is only slightly better than the function based on the original indexes.

Table 13
Classification Results of Discriminant Function Analysis Using Proposed WRAML Factors

		Predicted Group Membership			
		ADHD		Control	
Actual Group	*N*	*n*	%	*n*	%
ADHD	57	32	56.1	25	43.9
Control	62	27	43.6	35	56.4

Note. Percentage of grouped cases correctly classified = 56.3%. Prior probabilities set at .5 for each group.

DISCUSSION

The results of this study suggest that non-learning disordered children with ADHD do not score differently from those without ADHD on the subtests, indexes, or proposed factors of the WRAML, including the Attention factor put forth by Burton and his associates (1996). Therefore, the WRAML does not seem effective in aiding the diagnosis of ADHD. Examination of significant covariates shows evidence that academic achievement, particularly in math, has a much greater effect on WRAML scores than does ADHD status. As a result, it seems that the WRAML may be helpful in the assessment of learning problems with or without ADHD. This should be a topic for future studies.

The present findings fill a gap in previous research by examining the performance of children with and without ADHD on all subtests, indexes, and proposed factors while adjusting for individual differences in intellectual functioning and academic achievement. These results also help to explain some apparent contradictions in past results, which have inconsistently shown differences between the groups. The current findings agree with most of the other studies that have controlled for academic achievement levels in some manner (e.g., Phelps, 1996), finding no differences between the groups. This suggests that those studies finding differences between ADHD and non-ADHD groups may reflect disparate levels of academic achievement in the two groups. It would follow that the inconsistency between studies finding differences reflects various levels of achievement in their subject pools.

Compared with research on the memory skills of children with ADHD, this study accomplishes two things. First, it illustrates the importance of controlling for academic achievement level in the study of children with ADHD. Because of the high comorbidity of learning disorders in this population (e.g., Hinshaw, 1992; August & Garfinkel, 1990), score differences due to poor academic skills could easily be misinterpreted as the result of ADHD. Many memory studies do not mention achievement scores, making it impossible to figure out the most plausible cause of group differences. Second, the failure to find significant group differences on the types of tasks included on the WRAML supports the position put forth by some researchers (e.g., Denckla, 1996; Karatekin & Asarnow, 1998) that children with ADHD suffer not from straightforward memory deficits, but from deficits in working memory, an executive function involving not only the retention of information but the manipulation of that information while it is being held. This type of memory is not truly represented on the WRAML, which contains only direct recall and paired-associates learning tasks. These results also appear to say that simply having to rehearse information, as when trying to recall a series of numbers and letters (Number/Letter), a visual-spatial sequence (Finger Windows), or a lengthy sentence (Sentence Memory), may not tax working memory sufficiently to result in lower scores in children with ADHD as some (e.g., Loge et al., 1990) have suggested.

Although this study was not designed to test any particular theory regarding the nature of ADHD and thus cannot make any statements in that regard, the results are consistent with predictions made by recent theories proposing executive dysfunction--not problems with basic memory, attention, or learning, per se--as a common characteristic in individuals with ADHD (e.g., Pennington & Ozonoff, 1996; Denckla, 1996). As mentioned above, the children with ADHD in this study did not score significantly below their nondisordered counterparts the WRAML, which is thought to assess basic memory and possibly attention and concentration. No significant differences were found, despite the fact that the groups were defined to maximize the difference in their reported levels of inattention and motor activity. There are several possibilities for this finding. First, it is possible that these tests do not assess attention and concentration, as was previously thought. Second, it could be that, as Barkley (1997) has suggested, the core deficit of ADHD may not be inattention or poor concentration per se but a more basic inhibitory ability. Third, it is possible that these tests, while assessing a type of attention and concentration, simply do not tap the specific kinds of problems characteristic of children with ADHD. Again, while not directly supporting any theory, the present findings are in line with predictions made by those suggesting that the core deficit involved in ADHD lies at the level of executive functions or the more basic inhibitory ability. Finally, analyses in this study did not include measures of the internal consistency of the WRAML in order to verify the claims of adequate reliability made in the manual (Sheslow & Adams, 1993). Therefore, other possible explanations for the failure to find significant differences between groups could be related to test construction, reliability, or validity, aspects of which were not assessed during this study.

This study had several methodological strengths. First, the use of both criterion-based and norm-referenced measures from both a parent and a teacher increased the clarity and validity of the group definitions. Defining the groups in such a way to avoid any overlap of symptomology assured that the groups reflected the clear presence or absence of ADHD. Second, as mentioned previously, the consideration of cognitive functioning and academic achievement levels through exclusionary criteria and statistical controls helped to make sure that any differences found between the groups could be attributed to ADHD status.

Despite some improvements over past research, there are several ways in which this study could have been improved. First, structured diagnostic interviews with the parent and teacher as well as behavioral observations of potential subjects would have provided further evidence of diagnostic status beyond the rating scales used; however, these methods far exceeded the resources available for this study.

Second, by focusing only on the clearly defined groups described above, this study excluded children who exhibit marginal levels of inattention and/or hyperactivity or who exhibit such problems in only one setting. However, the intent of this study was not to determine the correlation between WRAML scores and behavioral ratings, but to explore differences between clearly defined clinical groups. Having found no significant differences between the extreme cases, this study diminishes the need to examine the pattern of scores across the entire spectrum of inattention and hyperactivity.

Third, although it has recently been suggested (Barkley, 1997, 1998) that the subtypes of ADHD may actually be two separate disorders with different characteristics, courses, and treatment outcomes, no distinction was made between the subtypes in this study, as making such a distinction would have severely reduced group sizes and made meaningful analyses impossible.

Fourth, although the present study considered academic achievement scores, the scores used for most subjects were from the standardized group-administered tests given by schools every year to two years. It is likely that children with ADHD score lower on these tests than on individually administered measures. Therefore, a methodological improvement would involve administering an individual achievement battery to every subject as opposed to relying on scores provided by schools. This would also reduce the possibility that the current study may have eliminated some non-learning disordered children with ADHD who scored poorly on the group-administered tests. If this were the case, the remaining subjects may have represented a subgroup of high achievers not representative of the ADHD population as a whole. Using an individually administered measure would also have provided the possibility for a substantial methodological improvement, the inclusion of a learning disordered comparison group. This would allow a more clear statement as to the relationship of WRAML scores to learning problems separate from ADHD.

Fifth, although comorbid learning disorders were controlled for by excluding any children with below average reading or math achievement scores, other comorbid conditions (e.g., conduct disorder, depression, anxiety) were not factored into subject selection or data analysis. The presence of comorbid disorders has generally been shown to enhance group differences (e.g., Seidman et al., 1995); however, given that no significant differences were found, it seems unlikely that the benefit would have offset the additional resources necessary for its inclusion.

Finally, as with many research studies, this study would have benefited from the inclusion of a more natural percentage of minority subjects in both the ADHD and control groups. Despite efforts to recruit minority subjects, few met all research criteria, and the precise reasons for this remain unclear. More research on the nature of ADHD and other disorders in minority populations is needed to increase the generalizability of findings to all children.

The findings of this study indicate needs for future research concerning ADHD and the use of the WRAML in clinical assessment. Regarding ADHD, it has been recommended by several researchers, (e.g., L. Phelps, personal communication, December 11, 1998) that research on the performance of children with ADHD include more measures of executive function, particularly working memory, and the more basic inhibitory skills (e.g., Barkley, 1997). The current study, along with other research on memory skills in children with ADHD, suggests that differences between groups on tests of basic memory disappear after controlling for levels of cognitive functioning and academic achievement. Where differences remain are on measures of working memory (e.g., Karatekin & Asarnow, 1998). Barkley's (1997) disinhibition theory offers one explanation of this mechanism and seems worthy of direct empirical investigation. Regarding the clinical use of the WRAML, the WRAML is clearly not useful in identifying children with ADHD, per se. However, the strong correlations between scores on the WRAML and on measures of academic achievement suggest that the test may be useful in the assessment and diagnosis of learning disorders. A direct assessment of this potential would be a logical next step in this line of research.

The current study was able to show that children with ADHD score no differently than their nondisordered peers on any subtest, index, or factor of the WRAML. Much emphasis is placed on the ways these children differ, generally in an unfavorable way, from their counterparts. This author believes it is at least as important to focus on how these children do *not* differ from their peers. It should be kept in mind that this is the only study to date to test the discriminative validity of the Burton et al. (1996) factors and one of only a few studies to examine differences on the individual subtests or original factors. Therefore, replication of these results will be needed in order to draw strong conclusions regarding the performance of children with ADHD on memory tasks or the usefulness of the WRAML in the assessment of ADHD.

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APPENDIX A

DSM-IV DIAGNOSTIC CRITERIA FOR ADHD

A. Either (1) or (2):

(1) six (or more) of the following symptoms of **inattention** have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

Inattention
(a) often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
(b) often has difficulty sustaining attention in tasks or play activities
(c) often does not seem to listen when spoken to directly
(d) often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
(e) often has difficulty organizing tasks and activities
(f) often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
(g) often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools)
(h) is often easily distracted by extraneous stimuli
(i) is often forgetful in daily activities

(2) six (or more) of the following symptoms of **hyperactivity-impulsivity** have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

Hyperactivity
(a) often fidgets with hands or feet or squirms in seat
(b) often leaves seat in classroom or in other situations in which remaining seated is expected
(c) often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
(d) often has difficulty playing or engaging in leisure activities quietly
(e) is often "on the go" or often acts as if "driven by a motor"
(f) often talks excessively

(Continued)

(Continued)

Impulsivity
(g) often blurts out answers before questions have been completed
(h) often has difficulty awaiting turn
(i) often interrupts or intrudes on others (e.g., butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.

C. Some impairment from the symptoms is present in two or more settings (e.g., at school [or work] and at home).

D. There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning.

E. The symptoms do not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder and are not better accounted for by another mental disorder (e.g., Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

Adapted from American Psychiatric Association, 1994

APPENDIX B

ORIGINAL PRINCIPAL COMPONENTS ANALYSIS OF WRAML SUBTESTS
(AGES EIGHT AND YOUNGER)

Subtests	Visual	Verbal	Learning
Picture Memory	* .569	-.148	.320
Design Memory	* .669	.078	.259
Verbal Learning	.311	.111	* .615
Story Memory	.285	* .222	.585
Finger Windows	* .655	.382	-.160
Sound Symbol	-.004	.125	* .749
Sentence Memory	.159	* .800	.320
Visual Learning	.605	.158	* .157
Number/Letter	.082	* .859	.113

* Subtests selected for respective indexes

Highest significant loadings for each subtest

Adapted from Sheslow & Adams (1990)

APPENDIX C

ORIGINAL PRINCIPAL COMPONENTS ANALYSIS OF WRAML SUBTESTS (AGES NINE AND OLDER)

Subtests	Visual	Verbal	Learning
Picture Memory	* .674	.012	.221
Design Memory	* .720	.023	.277
Verbal Learning	.239	.091	* .648
Story Memory	.216	* .196	.695
Finger Windows	* .584	.585	-.145
Sound Symbol	.214	.240	* .638
Sentence Memory	.017	* .749	.441
Visual Learning	.583	.076	* .401
Number/Letter	.005	* .837	.215

* Subtests selected for respective indexes

Highest significant loadings for each subtest

Adapted from Sheslow & Adams (1990)

APPENDIX D

PRINCIPAL FACTOR ANALYSIS OF WRAML SUBTESTS (AGES EIGHT AND YOUNGER): FOUR-FACTOR SOLUTION FROM GIOIA (1991)

Subtests	Nonverbal Memory	Verbal Span	Sound Symbol	Mixed Verbal-Nonverbal
Picture Memory	.243	.032	.078	* **.368**
Design Memory	* **.420**	.112	.062	* **.427**
Verbal Learning	.217	.135	.272	* **.420**
Story Memory	.088	.225	.159	* **.596**
Finger Windows	* **.382**	.224	.021	.192
Sound Symbol	.128	.127	* **.583**	.180
Sentence Memory	.098	* **.931**	.145	.258
Visual Learning	* **.536**	.115	.227	.144
Number/Letter	.209	* **.576**	.097	.076

*Subtests selected for respective factors

Highest significant loadings for each subtest

APPENDIX E

PRINCIPAL FACTOR ANALYSIS OF WRAML SUBTESTS (AGES NINE AND OLDER): THREE-FACTOR SOLUTION FROM GIOIA (1991)

Subtests	Mixed Verbal/ Nonverbal Memory	Verbal Span	Verbal Memory
Picture Memory	* .486	.070	.183
Design Memory	* .657	.082	.119
Verbal Learning	* .391	.183	* .306
Story Memory	.322	.193	* .659
Finger Windows	* .337	.283	.136
Sound Symbol	* .403	.283	.297
Sentence Memory	.151	* .686	.375
Visual Learning	* .591	.140	.175
Number/Letter	.129	* .823	.051

*Subtests selected for respective factors

Highest significant loadings for each subtest

APPENDIX F

ORTHOGONALIZED HIERARCHICAL FACTOR SOLUTION (AGES EIGHT AND YOUNGER) FROM GIOIA (1998)

Subtests	General Memory	Verbal Memory	Verbal Span	Visual Memory
Picture Memory	.412	.135	-.086	.019
Design Memory	.550	.123	-.027	.128
Verbal Learning	.535	.179	-.013	-.029
Story Memory	.569	.254	.042	-.213
Finger Windows	.394	.010	.140	.211
Sound Symbol	.384	.095	.060	.031
Sentence Memory	.513	.003	* .842	.004
Visual Learning	.495	-.003	.026	* .372
Number/Letter	.341	-.057	* .529	.162

* Subtests selected for respective factors

Highest significant loadings for each subtest

APPENDIX G

ORTHOGONALIZED HIERARCHICAL FACTOR SOLUTION (AGES NINE AND OLDER) FROM GIOIA (1998)

Subtests	General Memory	Visual Memory	Verbal Span	Verbal Memory
Picture Memory	.393	* .344	-.032	.030
Design Memory	.438	* .510	-.023	-.034
Verbal Learning	.467	.218	.055	.114
Story Memory	.683	.034	-.017	* .331
Finger Windows	.353	.219	.197	.023
Sound Symbol	.498	.220	.150	.105
Sentence Memory	.554	-.046	* .537	.183
Visual Learning	.462	* .430	.024	.009
Number/Letter	.360	.035	* .755	-.004

*Subtests selected for factors

Highest significant loadings for each subtest

APPENDIX H

PRINCIPAL COMPONENTS ANALYSIS OF WRAML SUBTESTS (AGES EIGHT AND YOUNGER) FROM WASSERMAN AND CAMBIAS (1992)

Subtests	Visual	Attention/ Immediate Recall	Verbally-Mediated
Picture Memory	* .569	-.148	.318
Design Memory	* .669	.078	.259
Verbal Learning	.310	.111	* .615
Story Memory	.287	.222	* .584
Finger Windows	* .655	* .382	-.160
Sound Symbol	-.004	.124	* .749
Sentence Memory	.159	* .800	.320
Visual Learning	* .604	.159	.157
Number/Letter	.081	* .860	.112

* Subtests selected for respective components
Highest significant loadings for each subtest

Total Variance = 56.1%

APPENDIX I

PRINCIPAL COMPONENTS ANALYSIS OF WRAML SUBTESTS (AGES NINE AND OLDER) FROM WASSERMAN AND CAMBIAS (1992)

Subtests	Verbally-Mediated	Visual	Attention/ Immediate Recall
Picture Memory	.223	* .673	.010
Design Memory	.278	* .720	.023
Verbal Learning	* .647	.240	.092
Story Memory	* .694	.216	.196
Finger Windows	-.147	* .586	*-.586
Sound Symbol	* .638	.215	.239
Sentence Memory	* .442	.016	* .749
Visual Learning	* .400	* .583	.076
Number/Letter	.216	.005	* .836

* Subtests selected for respective components
Highest significant loadings for each subtest

Total Variance = 59.7%

APPENDIX J

PAIRWISE PRINCIPAL FACTOR ANALYSIS OF WRAML SUBTESTS FROM AYLWARD ET AL. (1995)

Subtests	Visual Content	Short Term Verbal	Verbal Semantic/ Strategic
Picture Memory	* .424	-.034	.170
Design Memory	* .514	.043	.202
Verbal Learning	.199	.150	* .526
Story Memory	.053	.208	* .634
Finger Windows	* .493	.198	-.028
Sound Symbol	.146	.046	.323
Sentence Memory	-.049	* .688	.357
Visual Learning	* .670	-.026	.161
Number/Letter	.120	* .673	.106

*Subtests selected for respective factors due to loadings of .40 or higher
Highest significant loadings for each subtest

Total Variance = 36.3%

APPENDIX K

PRINCIPAL COMPONENTS FACTOR ANALYSIS OF WRAML SUBTESTS FROM PHELPS (1995)

Subtests	Attention/ Concentration	Visual Memory	Verbal Memory
Picture Memory	.26	* .69	-.12
Design Memory	* .56	.45	.17
Verbal Learning	-.01	.18	* .83
Story Memory	.37	-.01	* .72
Finger Windows	.03	* .75	.11
Sound Symbol	.14	* .59	.44
Sentence Memory	* .84	.14	.15
Visual Learning	-.21	* .50	.36
Number/Letter	* .81	-.03	.03

* Subtests selected for respective factors
Highest significant loadings for each subtest

Total Variance = 60.4 %

APPENDIX L

PRINCIPAL COMPONENTS FACTOR ANALYSIS OF WRAML SUBTESTS (ADHD GROUP) FROM DEWEY ET AL. (1997)

Subtests	**Verbal Attention/ Concentration**	**Verbal**	**Visual**
Picture Memory	-.05	* .56	.35
Design Memory	-.09	.01	* .68
Verbal Learning	.21	* .37	.11
Story Memory	.25	* .75	-.03
Finger Windows	.02	.09	* .59
Sound Symbol	-.17	* .72	-.10
Sentence Memory	*.83	.14	-.14
Visual Learning	.12	.02	* .68
Number/Letter	*.87	-.02	.16

* Subtests selected for respective factors
Highest significant loadings for each subtest

Total Variance = 51.6 %

APPENDIX M

PRINCIPAL COMPONENTS FACTOR ANALYSIS OF WRAML SUBTESTS (READING DISORDER GROUP) FROM DEWEY ET AL. (1997)

Subtests	Visual	Attention/ Concentration	Verbal
Picture Memory	*.7000	-.3000	-.1300
Design Memory	*.5800	-.0005	.2800
Verbal Learning	*.7300	.2300	.2100
Story Memory	.0400	.0600	* .8300
Finger Windows	*.5300	* .4900	-.3300
Sound Symbol	.3100	.1000	* .7600
Sentence Memory	-.0200	* .8200	.1100
Visual Learning	*.7100	.2400	.2500
Number/Letter	.1000	.8200	.1100

* Subtests selected for respective factors
Highest significant loadings for each subtest

Total Variance = 62.6 %

APPENDIX N

PRINCIPAL COMPONENTS FACTOR ANALYSIS OF WRAML SUBTESTS (CONTROL GROUP) FROM DEWEY ET AL. (1997)

Subtests	Visual/Verbal Memory 1	Attention/ Concentration	Visual/Verbal Memory 2
Picture Memory	* .60	-.11	-.22
Design Memory	* .72	-.07	.10
Verbal Learning	* .68	-.02	-.14
Story Memory	* .44	.15	*-.53
Finger Windows	.13	.10	* .81
Sound Symbol	* .65	.31	-.03
Sentence Memory	.05	* .81	-.17
Visual Learning	* .71	-.04	.13
Number/Letter	-.10	* .79	.22

*Subtests selected for respective factors

Highest significant loadings for each subtest

Total Variance = 56.2 %

APPENDIX O

BEST STRUCTURAL EQUATIONS MODEL FROM BURTON ET AL. (1996)

Subtests	Nonverbal	Verbal	Attention
Picture Memory	* .446	.000	.000
Design Memory	* .628	.000	.000
Verbal Learning	.000	* .570	.000
Story Memory	.000	* .624	.000
Finger Windows	* .346	.000	* .158
Sound Symbol	.000	* .432	.000
Sentence Memory	.000	.000	* .963
Visual Learning	* .512	.000	.000
Number/Letter	.000	.000	* .614

* Subtests selected for respective factors

Significant loadings for each subtest

APPENDIX P

FORM LETTER TO PARTICIPATING PARENTS

Dear Parent:

Thank you for agreeing to participate in the Children's Learning and Memory Study. Your participation will help us learn more about the learning and memory skills of school-aged children. To participate, simply complete the forms in this packet and return them to us. If your child is needed for the study (based primarily on age, gender, and grade level), we will send a similar packet to your child's teacher and obtain your child's most recent achievement test scores. Rest assured that all of this information will be kept strictly confidential. After we receive this information from your child's teacher, we will call you and schedule a learning and memory assessment for your child. The test session lasts one to one and a half hours and can be scheduled on a Saturday to avoid conflicting with school attendance. The test resembles a series of puzzles and games that require learning and memory skills. In exchange for your assistance, we will provide you with brief feedback on your child's performance. If you have any questions, please call Heather Scheffler at (504)388-8745. Thank you for your time and effort.

Sincerely,

Heather B. Scheffler, M. A.
Principal Researcher

Mary Lou Kelley, Ph.D.
Supervisor

P.S. If your child takes a medication such as Ritalin, Cylert, or Dexedrine that affects his or her behavior, please complete the enclosed forms based on his or her behavior when *not* on this medication.

APPENDIX Q

LOUISIANA STATE UNIVERSITY-BATON ROUGE CAMPUS CONSENT FORM

1. Study Title: Examining the Learning and Memory Skills of School-Aged Children

2. Performance Sites: Louisiana State University

3. Investigators: The following investigators are available for questions:

   Name: Heather B. Scheffler, M.A.
   Department: Psychology
   Telephone: 388-8745 (8:30-4:30 Mon.-Fri.)
   388-1494 (8-8 Mon.-Thur., 8-4:30 Fri.)
   358-1321 (24-hour)

4. Purpose of the Study: By participating in the study, volunteers will help to examine the learning and memory skills of school-aged children.

5. Patient Inclusion: The study includes children aged 5-13 years enrolled in grades 1-6.

6. Patient Exclusion: Children younger that 5 or older than 13, who are not enrolled in grades 1-6, or who have serious neurological problems are excluded.

7. Description of the Study: Behavior rating scales will be completed by the child's mother and teacher, and the child will participate in a 60 to 90-minute standardized testing session. About 100 volunteers will be recruited during the 24 months that the study is active.

8. Benefits: Parents will be offered feedback on their child's performance on the test of learning and memory in exchange for participating in the study.

9. Risks: There are no risks to participating in this study.

10. Alternatives: The study does not evaluate a different treatment; therefore, it is not an alternative.

11. Removal: Children who meet the inclusion criteria, whose parent and teacher complete the behavior rating scales, and who participate in the testing session have fulfilled all the study requirements once testing is complete.

12. Right to Refuse: Children (and their parent) may choose NOT to participate or withdraw from the study at any time with no penalty.

13. Privacy: The results of the study may be published. The privacy of the participating children and their families will be protected and the identity of participants will not be revealed. All information will be kept confidential.

14. Release of Information: The behavior ratings and test performances of the participants will be reviewed by the investigators, but participant identity will be kept secret. Information will be released to an outside service provider specified by the parent only if the parent completes a Consent to Release form.

15. Financial Information: There is no charge for participating in this study.

16. Signatures:

The study has been discussed with me and all my questions have been answered. I understand that additional questions regarding the study should be directed to investigators listed above. I understand that is I have questions about subject rights, or other concerns, I can contact the vice chancellor of the LSU Office of Research and Economic Development at 388-5833. I agree with the terms above and acknowledge I have been given a copy of the consent form.

____

Parents, please explain this form to your child and have them sign here. Date

____

Signature of the Volunteer Participant (Parent or Guardian) Date

____

Investigator(s) Date

The study subject has indicated to me that the subject is unable to read. I certify that I have read this consent form to the subject and explained that by completing the signature line above the subject has agreed to participate.

____

Signature of Reader Date

APPENDIX R

SCHOOL/TELEPHONE CONTACT CONSENT FORM

Principal Researcher: Heather B. Scheffler, M.A.
Supervisor: Mary Lou Kelley, Ph.D.

Child's Name: ______________________ Date of Birth: ________________

The above researchers have my permission to contact my child's school and teacher(s) regarding my child's performance and behavior in the classroom. Information obtained from my child's school and teacher(s) may include behavior rating scales and standardized achievement test scores. I understand that any information obtained about my child will remain strictly confidential and will be used for research purposes only. My child's teacher(s) and school have my permission to release this information to the researchers.

The researchers also have my permission to contact me by telephone in order to schedule a testing session (approximately 90 minutes in duration) for my child.

____

Signature of Parent Date

____

Parent's Name (Please Print) Phone Number

School Name: ____

Address: ____

Teacher(s): ____

____

____

APPENDIX S

DEMOGRAPHIC INFORMATION FORM

The following information is used to ensure that all demographic groups are represented in the study. Please complete this form as completely and accurately as possible. All information will remain strictly confidential and will not negatively affect any services you are receiving.

- Child's Age:_________ Sex:____________ Race:______________ Grade:__________

Please list any behavioral, psychological, or neurological problems that your child has:

Parents' Marital Status (Check those that apply and indicate dates):

_____Married _____Separated _____Divorced _____Remarried _____Never Married ____Widowed

Please list all individuals currently living in the household with the child (No names, please):

Age Sex Relation to Child

- Mother's Age:_________ Highest Education Level:_________________________________

Occupation (be specific):___________________________________ Income:________________

Is this the child's (check one): _____natural mother _____stepmother _____adoptive mother

_____foster mother _____guardian _____other (explain): ______________________________

Is the mother presently living in the home with the child? _____Yes _____No

(If no, is mother currently providing financial support? _____Yes _____No)

- Father's Age:_________ Highest Education Level:_________________________________

Occupation (be specific):___________________________________ Income: ________________

Is this the child's (check one): _____natural father _____stepfather _____adoptive father

_____foster father _____guardian _____other (explain):______________________________

Is the father presently living in the home with the child? _____Yes _____No

(If no, is father currently providing financial support? _____Yes _____No)

- If an additional adult provides financial support for the child, please complete the following:

Relation to Child: ____________________ Highest Education Level:_______________________

Occupation (be specific):___________________________________ Income:________________

APPENDIX T

RATING SCALE FOR RESEARCH

Child's Name: ______________________ Age: __________ Grade: ________
Completed by ______________________ Relationship: ______________________

Circle the number in the one column that best describes this child.

	Not at All	Just a Little	Pretty Much	Very Much
1. Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities	0	1	2	3
2. Often has difficulty sustaining attention in tasks or play activities	0	1	2	3
3. Often does not seem to listen when spoken to directly	0	1	2	3
4. Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)	0	1	2	3
5. Often has difficulty organizing tasks and activities	0	1	2	3
6. Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)	0	1	2	3
7. Often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools)	0	1	2	3
8. Is often distracted by extraneous stimuli	0	1	2	3
9. Is often forgetful in daily activities	0	1	2	3
10. Often fidgets with hands or feet or squirms in seat	0	1	2	3
11. Often leaves seat in classroom or in other situations in which remaining seated is expected	0	1	2	3
12. Often runs about or climbs excessively in situations in which it is inappropriate	0	1	2	3
13. Often has difficulty playing or engaging in leisure activities quietly	0	1	2	3
14. Is often "on the go" or often acts as if "driven by a motor"	0	1	2	3
15. Often talks excessively	0	1	2	3
16. Often blurts out answers before questions have been completed	0	1	2	3
17. Often has difficulty awaiting turn	0	1	2	3
18. Often interrupts or intrudes on others (e.g., butts into conversations or games)	0	1	2	3

In general, how old was this child when these behaviors first became a problem? ____________

Circle the setting(s) in which these behaviors cause problems for this child:

HOME SCHOOL CHURCH CLUB/PEER ACTIVITIES OTHER: ____________________

APPENDIX U

FORM LETTER TO PARTICIPATING TEACHERS

____________________, _______

Dear Teacher:

Your student, ______________________________, is participating in a research project through the LSU Department of Psychology. This study is examining the learning and memory skills of school-aged children. To assist with this investigation, we ask that you might complete the enclosed behavior rating scales and return them to us in the envelope provided. A copy of the consent form signed by the parent is enclosed for your reference. If you have any questions, please call Heather Scheffler at (504)388-8745. Thank you for your valuable assistance in this endeavor.

Sincerely,

Heather B. Scheffler, M. A.
Principal Researcher

Mary Lou Kelley, Ph.D.
Supervisor

<u>NOTE REGARDING STUDENTS ON RITALIN, DEXEDRINE, ADDERALL, ETC.</u>:

Please complete the rating scales based on this student's behavior when OFF medication. If you have never seen this child off medication or you are unsure of the child's status regarding medication, please base your responses on the student's typical classroom behavior. Please indicate below whether your ratings are based on this child's behavior when on or off medication. Thank you.

(Check one):
_____Ratings based on student's behavior when OFF medication.
_____I have never seen this student off medication. Ratings based on everyday behavior.
_____I don't know if this student is on medication. Ratings based on everyday behavior.

APPENDIX V

FORM LETTER REQUESTING ACHIEVEMENT TEST SCORES

______________________, ________

To whom it may concern:

A student at your school, ______________________________, is participating in a research project through the LSU Department of Psychology. This study is examining the learning and memory skills of school-aged children. To assist with this investigation, we ask that you might provide a copy of the child's most recent standardized test scores. A copy of the consent form signed by the parent is enclosed for your reference. If you have any questions, please call me at (504)388-8745. Thank you for your valuable assistance in this endeavor.

Sincerely,

Heather B. Scheffler, M. A.
Principal Researcher

Mary Lou Kelley, Ph.D.
Supervisor

VITA

Heather Brewis Scheffler was born in 1970 to Lyndell Ray Brewis and Kathryn Anne Porter Brewis in Birmingham, Alabama. She has one older sister, Ashley Brewis White. Heather received her bachelor of science degree in psychology in 1992, graduating with honors from The University of Alabama. She married Scott Alan Scheffler in July 1993. Heather received her master of arts degree in psychology from Louisiana State University and Agricultural and Mechanical College in 1995. She completed her clinical psychology residency through the Oklahoma Health Consortium in 1998. She will receive the degree of Doctor of Philosophy in psychology in May 1999. Heather and Scott currently live in Pittsboro, North Carolina.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Heather Brewis Scheffler

Major Field: Psychology

Title of Dissertation: Discriminative Validity of the Wide Range Assessment of Memory and Learning (WRAML) with Children with and without Attention-Deficit/Hyperactivity Disorder (ADHD)

Approved:

Mary Lou Kelley
Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

March 9, 1999

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989